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2 November 1978

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USSR AND EASTERN EUROPE SCIENTIFIC ABSTRACTS

PHYSICS

No. 46

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JPRS 72170

2 November 1978

## USSR AND EASTERN EUROPE SCIENTIFIC ABSTRACTS

### PHYSICS

No. 46

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Acoustics

USSR

UDC 534.232.46-8:681.88

DIRECTIONAL CHARACTERISTICS OF CYLINDRICAL ULTRASONIC HYDROPHONES

Moscow IZMERITEL'NAYA TEKHNIKA in Russian No 6, Jun 78 pp 74-76

BELASHCHENKO, G. I. and YENYAKOV, A. M.

[Abstract] The radiation pattern is calculated for a hollow cylindrical piezoelectric element in the plane that includes the axis of the cylinder in axisymmetric vibration. It is shown that the directional characteristic of such a hydrophone is a complex function. Since most cases involve operations with the amplitude characteristic, the analysis is restricted to the absolute values of the exponential function that describes the pressure developed by the cylinder. It is shown that troughs in the radiation pattern depend on the ratio between the height of the cylinder and the wavelength. A uniform radiation pattern is produced by a cylinder that meets the criterion  $h < c/f$ , where  $h$  is the height of the cylinder,  $c$  is the speed of sound in water and  $f$  is the upper frequency of the working band of the hydrophone. A technique is proposed for determining the optimum height of the cylinder to maximize uniformity by plotting curves for the nonuniformity of the directional pattern as a function of height of the cylinder for different frequencies; the minima on these plots give the optimum height. Figures 4; references 2 (Russian).

USSR

UDC 621.373.424:53.089.68

AN ACOUSTO-OPTICAL DOPPLER SIGNAL SIMULATOR

Moscow IZMERITEL'NAYA TEKHNIKA in Russian No 6, Jun 78 pp 34-36

KOSOVSKIY, L. A.

[Abstract] A Doppler signal simulator is considered that is based on a Bragg acousto-optical modulator enabling frequency shifts up to hundreds of MHz, as well as attenuation of the power of an optical signal linearly over a wide dynamic range by using electric attenuators. Emission is modulated by a narrow-band noise signal that approaches an actual Doppler signal in structure. The theory of modulation of laser emission by a noise signal using an acousto-optical modulator is explained. It is shown that difficulties involving measurement of weak signals to determine the spectral power density of the simulator signal can be obviated by using the relation between the energy spectra of radiation in the diffracted and zero orders. The steps involved in calibration are explained. A block diagram of the device is given. Figures 2; references 10: 8 Russian, 2 Western.

USSR

A NEW MECHANISM OF ONSET OF ACOUSTICAL-ELECTRIC CURRENT IN LIQUID AND GASEOUS CONDUCTORS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 5, May 78 pp 1037-1038 manuscript received 4 Apr 77

ANDREYEV, P. A., Leningrad Polytechnical Institute imeni M. I. Kalinin

[Abstract] Previous research by this author has shown that when an acoustic flux passes through a liquid or gaseous medium in a closed circuit, an acoustical-electric current is induced. The assumed mechanism for this effect was the nonlinear interaction between the transmitted acoustic wave and the magnetic field created by this wave. In this paper it is shown that an acoustical-electric current can also arise through the interaction of an external magnetic field with a liquid or gas in aperiodic motion due to the passage of sufficiently powerful acoustic fluxes. It is shown that the acoustical-electric currents due to both mechanisms are comparable when the ratio  $\gamma y_0^2 \omega / 4 \nu k$  is of the order of 10 or more, where  $\gamma$  is the coefficient of attenuation of the acoustic wave,  $y_0$  is the half-height of a semi-infinite layer of the medium (bounded on the left by the  $xz$ -plane),  $\omega$  is the frequency of the acoustic wave and  $\nu$  is the coefficient of kinematic viscosity. As an example it is shown that for mercury  $y_0 > 1$  cm satisfies this condition on an acoustic wave of 1 MHz in a magnetic field of  $8 \cdot 10^5$  A/m. Figure 1; references 4 (Russian).

USSR

UDC 534.232

GENERATION OF SOUND IN A LIQUID BY LASER PULSES OF ARBITRARY FORM

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 24 No 4, Jul/Aug 78 pp 534-539 manuscript received 3 Feb 78

KASOYEV, S. G. and LYAMSHEV, L. M., Institute of Acoustics, USSR Academy of Sciences

[Abstract] Generation of sound in a liquid by positive laser pulses is analyzed, these pulses assumed to be of arbitrary form but with an envelope each which ensures the existence of integrals and the convergence of series in the mathematical solution of the problem. Accordingly, the intensity of a laser beam impinging from air on water is expressed as  $I(x,y,t) = H(x,y)f(t)$ , where  $H(x,y)$  denotes the surface distribution of intensity and  $f(t)$  denotes a function of time determining the pulse form (Max  $f(t)=1$ ). The spectrum of acoustic pressure generated by such a laser beam is described by the

Helmholtz equation of diffraction. This problem is now solved for the steady state, with a Gaussian surface distribution of intensity, and two extreme cases: the acoustic delay time in a transverse plane through the generation zone either much shorter or much longer than the duration of a laser pulse. This analysis based on the thermal mechanism reveals that laser pulses of long duration generate acoustic pulses whose form is determined solely by the envelope of such a laser pulse, and that laser pulses of short duration generate acoustic pulses whose form is determined solely by the ratio of characteristic times. This method of analysis can be extended to the case of a liquid with surface ripples. Figures 3; references 9: 4 Russian, 5 Western.

Crystals and Semiconductors

USSR

UDC 621.378.3

INVESTIGATION OF THE LASING AND LUMINESCENCE PROPERTIES OF FLUORITE AND STRONTIUM FLUORIDE CRYSTALS DOPED WITH DIVALENT DYSPROSIUM

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA. SPEKTROSKOPIYA LAZERNYKH KRISTALLOV S IONNOY STRUKTURYOY [Transactions of the "Order of Lenin" Physics Institute imeni P. N. Lebedev. Spectroscopy of Laser Crystals with Ionic Structure] in Russian Vol 60, 1972 pp 84-130

ZOLOTOV, YE. M.

[Abstract] An investigation is made of the quantum yield and losses in fluorite and strontium fluoride crystals activated by dysprosium to find the limiting lasing efficiency, to determine the lifetime on excited levels, to explain the part played by these levels in stimulated emission and to determine the oscillator strength of the lasing transition in these crystals. Ruby and neodymium glass lasers operating in different modes of stimulated emission were used for pumping the  $\text{CaF}_2\text{-Dy}^{2+}$  and  $\text{SrF}_2\text{-Dy}^{2+}$  crystals. The quantum yield from the absorption band on the metastable level as measured by absorption compensation of luminescence was found to be 0.9-0.95 for fluorite and about 0.4 for strontium fluoride. It is found that the quantum yield from the absorption band is independent of the region into which stimulation takes place or temperature in the 77-300 K range. Absorption spectra are found for excitation of divalent dysprosium from the metastable level in these crystals. The time of transition of ions from the absorption band to the metastable level is found to be about 5-15 ns in activated fluorite. The estimated lifetime of  $\text{Dy}^{2+}$  ions within the absorption band does not exceed 0.5 ns. It is found that the  $^5\text{I}_6$  term in dysprosium-doped fluorite is not a bottleneck. The author thanks M. D. Galanin, A. A. Mak and V. V. Osiko for constructive comments, V. B. Biryukov and S. V. Obraztsov for assistance with the work, M. V. Dmitruk and S. Kh. Batygov for growing the crystals, G. P. Shipulo for constructive criticism and continued support, and Academician A. M. Prokhorov for assistance. Figures 26; references 80: 44 Russian, 36 Western.

USSR

UDC 547.41'786+546.657.3

OPTICAL PROPERTIES OF Nd<sup>3+</sup> IN SINGLE CRYSTALS OF LANTHANUM OXYFLUORIDE

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA.  
SPEKTROSKOPIYA LAZERNYKH KRISTALLOV S IONNOY STRUKTURYO [Transactions of the  
"Order of Lenin" Physics Institute imeni P. N. Lebedev. Spectroscopy of Laser  
Crystals with Ionic Structure] in Russian Vol 60, 1972 pp 72-76

OSIKO, V. V., SOBOL', A. A., TIMOSHECHKIN, M. I. and FURSIKOV, M. M.

[Abstract] The specific properties of neodymium-activated rare earth oxy-fluorides are studied as exemplified by the optical properties of single crystals of LaOF activated by Nd<sup>3+</sup>. These crystals have a melting point of 2000°C, Mohs hardness of 6, density of 5.94 g/cc, optical transparency at wavelengths of 0.26-10 μm, index of refraction n<sub>g</sub> of 1.795 ± 0.001 and index of refraction n<sub>p</sub> of 1.780 ± 0.001. The crystal composition did not correspond to the stoichiometric formula and contains an excess of LaF<sub>8</sub> (no more than 2 mol.%). Detailed absorption spectra are given in the group  $^4I_{9/2} \rightarrow ^4F_{3/2}$ , and luminescence spectra--in the groups  $^4F_{3/2} \rightarrow ^4I_{9/2}$ ,  $^4I_{11/2}$  at 4.2, 77 and 295 K. Based on the absorption and luminescence spectra, a scheme is proposed for splitting of levels  $^4F_{3/2}$ ,  $^4I_{9/2}$ ,  $^4I_{11/2}$  in LaOF.

Polarization measurements of the absorption spectra show appreciable anisotropy of the crystal field in LaOF. The spectral lines of absorption and luminescence remain broad throughout the investigated temperature range, showing disordered structure in these single crystals. The measured lifetime of the metastable level  $^4F_{3/2}$  remains practically unchanged with transition from 77 to 295 K. No concentration quenching of luminescence is observed with variation in activator concentration from 0.1 to 2.5 at %. Figures 4; references 10: 5 Russian, 5 Western.

USSR

UDC 546.41'786+546.61

## Nd<sup>3+</sup> OPTICAL CENTERS IN CALCIUM AND STRONTIUM FLUOROPHOSPHATE CRYSTALS

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA.  
SPEKTROSKOPIYA LAZERNYKH KRISTALLOV S IONNOY STRUKTUROY [Transactions of the  
"Order of Lenin" Physics Institute imeni P. N. Lebedev. Spectroscopy of  
Laser Crystals with Ionic Structure] in Russian Vol 60, 1972 pp 57-71

MAKSIMOVA, G. V. and SOBOL', A. A.

[Abstract] A detailed investigation is made of the absorption and luminescence spectra of Nd<sup>3+</sup> in crystals of calcium fluorophosphate Ca<sub>5</sub>(PO<sub>4</sub>)<sub>3</sub>F and its crystal-chemical analog strontium fluorophosphate with different activator concentrations as a basis for analyzing the Nd<sup>3+</sup> optical centers in these crystals. The crystals were grown by the Czochralski method from iridium crucibles. Neodymium doping was from 0.25 to 0.7 at .% in the calcium fluorophosphate crystals, and from 0.02 to 0.4 at .% in the strontium fluorophosphate crystals. The spectra were studied at 4.2, 77, and 295 K. It is noted that several different types of Nd<sup>3+</sup> optical centers may be present in these crystals. The number and concentration of these centers depends appreciably on conditions of growth. Some calcium fluorophosphate specimens showed only an M center, while others with the same activator concentration showed M, P and N centers. The N centers showed luminescence quenching in contrast to the M and P centers. The strontium fluorophosphate crystals showed a large number of Nd<sup>3+</sup> optical centers, some analogous to the M and P centers in the calcium counterparts. None of the strontium crystals showed only one Nd<sup>3+</sup> center. Diagrams are proposed for splitting of the <sup>4</sup>F<sub>3/2</sub> level and the levels of the <sup>4</sup>I multiplet for the M center in calcium fluorophosphate, and levels <sup>4</sup>F<sub>3/2</sub>, <sup>4</sup>I<sub>9/2</sub>, <sup>4</sup>I<sub>11/2</sub> for the M center of Nd<sup>3+</sup> in strontium fluorophosphate. The nature of these optical centers is discussed, and possible models are proposed. The authors thank V. V. Osiko for constructive criticism. Figures 11; references 13: 5 Russian, 8 Western.

USSR

UDC 535.343+535.371

**Nd<sup>3+</sup> SPECTROSCOPIC OPTICAL CENTERS IN CaF<sub>2</sub> AND SrF<sub>2</sub> CRYSTALS**

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA.  
SPEKTROSKOPIYA LAZERNYKH KRISTALLOV S IONNOY STRUKTUROY [Transactions of the  
"Order of Lenin" Physics Institute imeni P. N. Lebedev. Spectroscopy of  
Laser Crystals with Ionic Structure] in Russian Vol 60, 1972 pp 31-56

BATYGOV, S. KH., VORON'KO, YU. K., DMITRUK, M. V., OSIKO, V. V., PROKHOROV,  
A. M. and SHCHERBAKOV, I. A.

[Abstract] The authors study the Nd<sup>3+</sup> centers in a series of crystals:  
SrF<sub>2</sub>-Nd<sup>3+</sup> (0.002-0.016 wt.% NdF<sub>3</sub>), CaF<sub>2</sub> (0.002-0.5 wt.% NdF<sub>3</sub>), CaF<sub>2</sub>-Nd<sup>3+</sup>.  
TR<sup>3+</sup> (0.07 wt.% NdF<sub>3</sub>, 0.14 wt.% TRF<sub>3</sub>, 0.07 wt.% NdF<sub>3</sub>, 0;35 wt.% TRF<sub>3</sub>) to  
get quantitative evaluations of the equilibrium of centers, the probability  
of transitions and processes of quenching of Nd<sup>3+</sup> by other TR<sup>3+</sup> ions. The  
lower limit of bonding energy in a tetragonal center is determined. An in-  
vestigation is made of the optical centers that are induced in CaF<sub>2</sub>-Nd<sup>3+</sup>  
crystals by a second impurity and by exposure to gamma radiation. The life-  
time of the excited state of the Nd<sup>3+</sup> ion is measured in some of these cen-  
ters. Analysis of experimental data shows that a Y center consists of one  
Nd<sup>3+</sup> ion and two fluorine ions situated in adjacent interstices. The authors  
thank V. A. Myzina and V. S. Fedorov for assisting with the experiments and  
formulation of the work. Figures 21; references 39: 27 Russian, 12 Western.

USSR

UDC 621.375.826

**SURFACE DESTRUCTION OF SOLID TRANSPARENT DIELECTRICS BY LASER EMISSION**

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 5(71), 1978 pp 1151-1154  
manuscript received 8 Sep 77

KOVALEV, A. A. and MAKSHANTSEV, B. I.

[Abstract] Previous attempts to apply to fluctuation theory of destruction  
of solid transparent dielectrics to surface damage have failed to account  
for the influence of the surface itself. This paper attempts to account  
for the surface influence in explaining experimentally observed surface de-  
struction by laser radiation. A dielectric is considered that has trans-  
parent nonhomogeneities which are regions with high local concentration of  
impurity centers that absorb laser emission and dissipate it as heat as a  
consequence of nonradiative electron transitions. The authors consider the

case where the thermal instability that causes destruction is initiated by a spherical nonhomogeneity in the dielectric at a depth much less than the radius of the sphere. It is assumed that the heat conduction of the non-homogeneity is much greater than that of the dielectric, so that the temperature inside the inclusion is independent of coordinates. It is shown that the average breakdown density of laser power is much less in the case of surface destruction than for volumetric destruction. The theoretical results agree with experimental data, and provide a physical interpretation for the observed increase in the threshold of surface destruction when surface treatment is used. This increase can be attributed to a reduction in the dimensions of absorbing nonhomogeneities on the dielectric surface as a result of treatment. Figures 14: 13 Russian, 1 Western.

USSR

UDC 621.3.038.8:539.4

INVESTIGATION OF THE RESISTANCE OF KRS-6 AND KRS-5 CRYSTALS TO THE ACTION OF PULSED CO<sub>2</sub> LASER RADIATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5, No 5(71), May 78 pp 1043-1047  
manuscript received 26 May 77

DARVOYD, T. I., KOVALEV, V. I., LISITSKIY, I. S., MIRONOV, V. S. and FAYZULLOV, F. S., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] From a study of the spectral transmission, light scattering and resistance to laser pulses for thallium bromide-chloride (KRS-6) crystals grown in air and in vacuum, it is found that anionic impurities (mainly sulfur) reduce both spectral transmission and strength in thallium halide. Crystals grown under conditions that eliminate these impurities have a considerably higher threshold of destruction on a laser wavelength of 10.6 um. Both KRS-6 and KRS-5 (thallium bromide-iodide) crystals have higher surface strength under laser radiation when they are polished with diamond powder and diamond paste than when surface treatment is with cerium oxide abrasive. Figures 3; references 7: 5 Russian, 2 Western.

USSR

FREQUENCY DOUBLING UPON PROPAGATION OF MAGNETIC PLASMA WAVES IN BISMUTH

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 20 No 6, Jun 78 pp 1779-1782  
manuscript received 5 Jan 78

LEVIYEV, G. I. and YASHCHIN, E. G., Institute of Solid State Physics, Academy  
of Sciences USSR Chernogolovka

[Abstract] Generation of the second harmonic is observed in a plate of single-crystal bismuth as a weakly damped magnetic plasma microwave propagates through it in 2 cases: with  $k$  perpendicular to  $H$  and  $k$  parallel to  $H$  (where  $k$  is the wave vector of the magnetic-plasma wave,  $H$  is the constant magnetic field). The experiment was performed at 4.2 K. It is found that as the magnetic-plasma wave propagates parallel to the magnetic field in the area of large fields, the harmonics are due to the resonances of the standing magnetic-plasma waves in the plate; in the area of smaller fields, quantum oscillation of the harmonic signal occurs. The power of the second harmonic is maximum when polarization of the electric field of the microwave on the fundamental coincides with that on the second harmonic. The power of the second harmonic with a monotonic increase proportional, to  $H^2$  undergoes very strong oscillations due to excitation of standing waves on both frequencies. The results show that the tendency toward growth of the power of the second harmonic is quite genuine. On the other hand, when the constant magnetic field is parallel to trigonal axis  $C_3$  (normal to the plane of the plate), the oscillations do not coincide with those predicted by theory. This may be due to the failure to account for quantum oscillations. And in fact, the experiment shows a very strong fluctuation in the power of the second harmonic indicating the possibility of "giant" quantum oscillations. The authors thank V. A. Tulin for discussing the results and the experimental technique. Figures 4; references 6: 5 Russian, 1 Western.

USSR

PHASE TRANSITIONS AND JAHN-TELLER DISTORTIONS IN RARE-EARTH ORTHOVANADITES

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 20 No 6, Jun 78 pp 1816-1821  
manuscript received 28 Oct 77; after revision 16 Jan 78

BORUKHOVICH, A. S., ZUBKOV, V. G. and BAZUYEV, G. V., Institute of Chemistry,  
Urals Scientific Center, Academy of Sciences, USSR Sverdlovsk

[Abstract] A study is made of the magnetic and thermodynamic parameters of cerium, gadolinium and lutetium orthovanadite. Polytherms of heat capacity, magnetization and magnetic susceptibility of these rare-earth orthovanadites are obtained in order to trace their change as functions of the ordinal number of the rare-earth element and possible peculiarities of the electron structure. It is established that there are anomalous characteristics of the magnetic and structural phase transitions. These anomalies are interpreted in terms of a Jahn-Teller displacement of the trivalent vanadium ion with respect to the octahedral surroundings. The rare-earth orthovanadites can be considered concentrated systems that contain Jahn-Teller ions. Since a vanadium Jahn-Teller ion compresses the octahedron, the magnetic ordering that occurs below the Neel point combines, with spin-orbital interaction to initiate a structural phase transition that is always lower in temperature than the magnetic phase transition. The temperature difference between these transitions is a specific characteristic of the given compounds. Figures 3; tables 1; references 13: 7 Russian, 6 Western.

USSR

THE EXCITON-PLASMA TRANSITION IN SEMICONDUCTORS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 20 No 6, Jun 78 pp 1850-1855  
manuscript received 24 Jan 78

BISTI, V. YE. and SILIN, A. P., Institute of Physics imeni P. N. Lebedev,  
Academy of Sciences, USSR Moscow

[Abstract] The critical density of the exciton-plasma transition is determined for temperatures much less than the binding energy of the exciton on the basis of disappearance of the energy gap in the single-frequency excitation spectrum, based on dielectric shielding of the Coulomb interaction in the system of excitons. The problem is reduced to calculation of the energy portion of the electrons (or holes). The nature of phase transitions of a system of electrons and holes in isotropic one-valley semiconductors at low temperatures is discussed. The authors thank L. V. Keldysh for interest in the work and discussion of the results. Figures 4; references 17: 6 Russian, 11 Western.

USSR

UDC 621.382.232

CONDUCTIVITY-TYPE INVERSION IN  $n\text{-Cd}_x\text{Hg}_{1-x}\text{Te}$  ALLOYS UNDER THE INFLUENCE OF PULSED LASER RADIATION

PLYATSKO, H. V., SAVYTSKYY, V. H., LUTSIV, R. V., DRUZHYNIN, A. A., KOTLYARCHUK, B. V., KYYAK, S. H., Lvov Branch of Mathematical Physics, Institute of Mathematics of the Academy of Sciences UkrSSR, and Lvov State University

Kiev DOPOVIDI AKADEMIYI NAUK UKRAINS'KOYI RSR, SERIYA A, FIZYKO-MATEMATYCHNITA TEKHNICHE NAUKY in Ukrainian No 7, 1978 pp 645-647

[Abstract] The influence of pulsed laser radiation on the properties of n-type conductivity was investigated in solid solutions of  $\text{Cd}_x\text{Hg}_{1-x}\text{Te}$ . A conductivity-type inversion was found in the laser radiation zone and the p-n junction properties were also studied. Research showed that pulsed laser heating can be an effective method for forming inversion spheres and for forming p-n junctions in highly-doped semiconductor materials of  $\text{Cd}_x\text{Hg}_{1-x}\text{Te}$  with satisfactory electrophysical and photoelectric properties. Figures 2; references 12.

USSR

UDC 539.196.6

IMPULSE PRODUCTION OF COPPER VAPOR

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA No 10, FIZIKA, KHIMIYA in Russian issue 2, May 78 pp 131-135 manuscript received 4 Jun 77

SHUKHTIN, A. M., FEDOTOV, G. A. and MISHAKOV, V. G.

[Abstract] Three varieties of pulsed production of vapor were used: dissociative, separative and dust. Results are presented from interference measurements of the concentration of normal copper atoms at various moments in time after transmission of a current pulse through each of the three types of experimental volumes (copper iodide vapor, a tube with copper-lined interior walls, and a cloud of dust containing copper filings). Several facts are noted which concern the form of the function of the number of normal atoms present as a function of time. As the buffer gas pressure increases, the decrease in the concentration of normal atoms is retarded; as the diameter of the discharge tube increases, the decrease in concentration of normal atoms becomes slower; an increase in the capacitance of the discharge capacitor results in displacement of the maximum of the function in the direction of longer times. Figures 2; references 5 (Russian).

USSR

UDC 621.373.8:53.096

TEMPERATURE DISTRIBUTION OVER THE SURFACE OF SEMICONDUCTOR SOURCES OF INFRARED RADIATION

Tomsk IZVESTIYA VUZOV, FIZIKA in Russian No 6, Jun 78 pp 134-138 manuscript received 29 Jul 77

ZHARNIKOV, S. D., MANAK, I. S., and SHILOV, A. F., Belorussian State University imeni V. I. Lenin

[Abstract] The temperature distribution over the end surface of an infrared emitting GaAs diode was measured directly with a radiation pyrometer under various operating conditions. With the diode operating in the spontaneous mode, the temperature was found to vary most within the active region and proportionally to the current. Here the p-region becomes hotter than the n-region, which indicates that the energy generated by nonradiative transitions and scattered within a small lattice volume constitutes the main source of heat. The energy of spontaneous emission, absorbed within a large lattice volume of the highly doped p-region, is the other source of heat. The temperature of the passive regions rises as a result of heat conduction. With the diode operating in the laser mode, the temperature was found to become highest at the emitting spot. The heating of the diode, due to the Joule effect, was found to increase proportionally to the square of the pumping current and, at a constant current level, linearly with the pulse duration. The additional temperature rise at the emitting spot is attributable to absorption of the energy of stimulated emission and of the energy generated by nonradiative transitions. Figures 3; references 12: 5 Russian, 7 Western.

USSR

UDC 537.533

SELF-ACCELERATION OF A BEAM OF ULTRARELATIVISTIC ELECTRONS IN A SINGLE CRYSTAL

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 240 No 6, 1978 pp 1332-1335  
manuscript received 2 Mar 78

KALASHNIKOV, N. P. and OL'CHAK, A. S., Moscow Institute of Engineering Physics

[Abstract] The passage of an electron beam through a single crystal is considered and the probability of detecting electrons with an energy  $E_0 + \Delta E$  where  $\Delta E \gg m_e c^2$  is calculated. The number of electrons in a beam which have received such an increment of energy is determined from the Feynman diagram Möller scattering, and the relative contributions of this process and of reverse bremsstrahlung to the total self-acceleration are compared. Numerical

results are given for a diamond crystal ( $Z = 6$ ,  $n_{\text{atom}} = 1.75 \cdot 10^{23} \text{ cm}^{-3}$ )  $L = 6 \mu\text{m}$  thick and an electron beam  $d = 1 \text{ mm}$  in diameter with an electron concentration  $n_e = 10^{12} \text{ cm}^{-3}$  and an energy  $E_0 = 2.8 \text{ GeV}$ , with an average electron flux  $N_e = 10^{18} \text{ s}^{-1}$ . It is found necessary to take into account changes in the electron wave functions affecting the potentials of atoms in the crystal lattice. The paper was presented on 16 Mar 78 by academician N. G. Basov. Figures 4; references 6: 4 Russian, 2 Western.

Electricity and Magnetism

USSR

UDC 621.384.659

INVESTIGATION OF A DIODE WITH EXPLOSIVE EMISSION CATHODES AT LONG CURRENT PULSE DURATIONS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 46 No 7, Jul 78 pp 1494-1503 manuscript received 16 Sep 77

BURTSEV, V. A., VASILEVSKIY, M. A., GUSEV, O. A., YEFIMOV, A. B., ROYFE, I. M., SEREDENKO, YE. V. and ENGEL'KO, V. I., Scientific Research Institute of Electrophysical Apparatus imeni D. V. Yefremov, Leningrad

[Abstract] The paper gives the results of experiments in which studies were done on conditions of producing electron beams of long duration in a diode with multiple-point explosive emission cathodes for interelectrode gaps of about 10 cm, current densities of the order of  $1 \text{ A/cm}^2$  and electron energy of 50-400 keV. The pointed emitters were held on a disk inside a shield. Five kinds of emitters were studied: stainless steel foil triangles; pointed titanium rods; pointed graphite rods; pointed graphite rods behind an acrylic plastic plate with holes opposite each rod; bundles of graphite fibers. Experimental data are given characterizing the operation of the diode as dependent on cathode material, electric field intensity and electron current density. It is found that the beam of maximum duration (175  $\mu\text{s}$ ) is observed for bundles of graphite fibers at current densities on the anode of the order of  $0.1 \text{ A/cm}^2$ . Figures 7; references 14 (Russian).

USSR

UDC 537.533:537.528

THE NATURE OF EXPLOSIVE ELECTRON EMISSION ACCORDING TO DATA OF ELECTRIC EXPLOSION OF CONDUCTORS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 46 No 7, Jul 78 pp 1482-1493 manuscript received 24 Feb 77

MARTYNYUK, M. M., Friendship University imeni P. Lumumba, Moscow

[Abstract] The author considers the part played by explosive boiling (phase explosion) of molten metal in processes of electric explosion of conductors and electric explosion of sharp metal points. It is shown that when the current pulse duration is  $10^{-7}$ - $10^{-5}$  s the development of the explosion is determined by the steady-state process of homogeneous nucleation of vapor centers (steady-state phase explosion); at pulse durations of  $10^{-8}$  s or less, the steady-state nature of the process is disrupted. The temperature and current density of thermionic emission for a number of metals at the initial point of steady-state phase explosion are calculated from data for electric explosion of conductors; consideration is given to the influence of the

electric field on thermionic emission at this point. It is shown that in the vicinity of the initial point of electric explosion of conductors field emission decreases, giving way to explosive emission of electrons. An increase of current in the initial stage of development of explosive emission of electrons is determined by a sharp rise in thermionic emission intensified by the Schottky effect and by penetration of the electric field due to the metal-to-nonmetal transition. On the subsequent stage the emission current is intensified due to an increase in the emitting surface with explosive formation of a finely dispersed vapor-liquid mixture. It is pointed out that the kinetics of decay of the thermodynamically unstable phase may play a part in the process of unsteady electric explosion of sharp metal points and conductors. The temperature, current density and time of existence of an element of an explosive cathode spot of a vacuum arc are estimated on the basis of the results. It is shown that the minimum element of the cathode spot is a zone of phase explosion of a microprojection that periodically changes its position. Estimates for the case of a steady-state phase explosion give a time of formation of the micro-explosion of  $10^{-5}$ - $10^{-7}$  s, time of the explosion itself of about  $10^{-7}$  s, current density in the spot in the pre-explosion period of  $10^6$ - $10^7$  A/cm<sup>2</sup> and temperature of the spot at the instant before explosion somewhat higher than the boiling point of the metal. References 33: 26 Russian, 7 Western.

USSR

UDC 538.221

#### METALLIC GLASSES AND AMORPHOUS MAGNETISM

Moscow IZVESTIYA AKADEMII NAUK SSSR, SERIYA FIZICHESKAYA in Russian Vol 42 No 8, Aug 78 pp 1570-1580

VONSKOVSKIY, S. V. and TUROV, YE. A., Institute of Metal Physics, Ural Science Center of the USSR Academy of Sciences

[Abstract] Metallic glasses are amorphous solids in a metastable state frozen by superfast cooling, possible only if at least one dimension of a specimen remains small. Consequently, metallic glasses are produced in foil, ribbon, or wire form. Structurally they are characterized by a specific volume which does not change much upon transition from crystalline to amorphous state and by recrystallization only at a temperature slightly higher than the temperature of transition to the subcooled state. Their chemical composition is typically 80 atom.% of noble or transition metals and 20 atom.% of glass-forming nonmetals. Of particular interest are ferromagnetism and antiferromagnetism which may occur along with para- or diamagnetism. The ferrous glass Fe<sub>80</sub>B<sub>20</sub> has a Curie point, a saturation induction, and a remanence comparable to those of commercial iron-nickel or iron-silicon alloys. Upon heating its magnetization decreases with rising temperature, jumps up at the Curie point (647 K), and decreases again. Upon cooling

its magnetization increases monotonically to levels higher than in the heating cycle, thus displaying a hysteresis. Another glass with magnetic properties is Co<sub>80</sub>B<sub>20</sub>. Of further interest is low-temperature magnetism of these materials, which has already been predicted in amorphous ferromagnetics with a classical law of scattering and which to some extent has been studied experimentally, but the various anomalies of which have not yet been explained. Figures 8; tables 4; references 54: 6 Russian, 48 Western.

USSR

UDC 621.316.5:537.529

INVESTIGATION OF ELECTRICAL EXPLOSION OF CYLINDRICAL FOILS IN AIR. I.  
ELECTRICAL CHARACTERISTICS OF FOIL EXPLOSION

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 46 No 7, Jul 78 pp  
1419-1427 manuscript received 12 Sep 77

BURTSEV, V. A., LUBYANSKIY, V. A., YEGOROV, N. P., KASATKINA, M. P.,  
PRODUVNOV, A. B. and SHESTAKOV, I. V., Scientific Research Institute of  
Electrophysical Apparatus imeni D. V. Yefremov, Leningrad

[Abstract] Studies have shown that ionization phenomena and breakdown of the medium surrounding flat exploding foils take place mainly at the edges. In order to study electrical explosion of foil specimens with a considerable reduction in the part played by the edge effect, the authors did experiments with foil formed into a cylinder and coaxial feed of the electric current. Air at atmospheric pressure was used as the ambient medium, enabling observation of the explosive process by optical methods. The principal results of this research have been published previously [see Preprint K-0293, Scientific Research Institute of Electrophysical Apparatus, Leningrad, 1976]. A diagram of the experimental facility is presented and explained, and curves are given showing the time dependence of cylindrical foil explosion characteristics, thickness dependence of extreme values of electrical characteristics in foil explosion, resistivity of the foil as a function of specific energy, and temperature dependence of relative resistance. The results confirm observations with flat foils: increase in overvoltages with increasing current density, and anomalously low maximum relative resistances reached during explosion. The specific energy released at the instant of maximum resistance averages less than 50% of the energy necessary for vaporization in the case of aluminum foil. A more detailed study of the initial stage of heating of the foils showed that in the case of rapid pulse heating of aluminum in air, its resistance with energy input changes almost like the case of quasi-steady adiabatic heating. On the stage of direct explosion, a rather sharp increase in foil resistance is observed beginning approximately at the instant when the boiling point of aluminum is reached. The parameters of the exploding

conductor must be matched to those of the RLC tank circuit in the power supply to optimize the explosion process from the standpoint of energy input on the stage of direct explosion of the foil. Figures 6; references 23: 22 Russian, 1 Western.

Fluid Dynamics

USSR

UDC 532.517.4

ON THE NATURE OF TURBULENCE

Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 125 No 1, May 78 pp 97-122

MONIN, A. S., Institute of Oceanology, Academy of Sciences USSR

[Abstract] In this survey, turbulence is defined as random fluctuations in the thermohydrodynamic characteristics of swirling (twisted) flows, as distinguished from random potential flows, and the properties differentiating turbulence from waves are discussed. The author reviews L. D. Landau's theory that attributes turbulence to an increase in the Reynolds number as a result of a sequence of normal bifurcations that generates quasiperiodic motions. A number of examples are considered, including flow between rotating cylinders, convection at low Prandtl numbers and the boundary layer near a flat plate. The hypothesis of "strange attractors" is introduced, i.e. Cantor subsets of sets of non-wandering points exclusive of stationary points and closed trajectories. While there are no exact proofs of the presence of strange attractors in the phase spaces of flows of viscous fluids and gases, the hypothesis can be considered likely if the presence of strange attractors is typical in general of dynamic systems. Some results in this direction are discussed. Flows with inverse bifurcations are considered including planar Poiseuille flow and E. N. Lorenz's example of idealized trimodal convection in a fluid with high Prandtl number. The results of numerical analysis in the latter case indicate the possibility of a strange attractor with the structure of a Cantor ternary set. Other cases of systems with strange attractors are considered as well. It is pointed out that strange attractors cannot explain the continuous spatial spectrum that occurs in real turbulence.

Figures 10; references 77: 25 Russian, 52 Western.

## Lasers and Masers

USSR

UDC 621.378.325

### THERMAL GASDYNAMIC LASERS ON PARTIAL INVERSION

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 46 No 7, Jul 78 pp 1432-1441 manuscript received 10 Jun 77

ORAYEVSKIY, A. N., RODIONOV, N. B. and SHCHEGLOV, V. A., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] The authors consider the use of mixtures that allow partial inversion in gasdynamic lasers. It is shown that cooling of the preheated gas must be fairly deep to attain partial inversion by thermal pumping, the preferred molecules having high characteristic rotational temperature and rather low temperature for freezing out vibrations of the working molecules. Some possible gas mixtures are proposed, mainly with hydrogen (deuterium) halides as the working gas and N<sub>2</sub>, H<sub>2</sub>, D<sub>2</sub> and CO as the auxiliary gas. The rate of transfer of vibrational energy from the molecules of the auxiliary gas to the working molecule can be accelerated by introducing quasiresonant dopant molecules (DCl, NO, HI, CO). The conditions for freezing out vibrational energy in a supersonic flow are discussed, and the energy parameters are evaluated for a thermal gasdynamic laser that uses quasiresonant vibrational-vibrational exchange of quanta between working components. The expressions derived are used to evaluate the energy parameters of a laser using a mixture of D<sub>2</sub>-HCl-He. The results show good prospects for this mixture in the proposed type of laser. Figures 4; references 17: 9 Russian, 8 Western.

USSR

UDC 535.343+535.371

### SOME PROBLEMS OF SPECTROSCOPY OF LASER CRYSTALS WITH IONIC STRUCTURE

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA. SPEKTROSKOPIYA LAZERNYKH KRISTALLOV S IONNOY STRUKTUROY [Transactions of the "Order of Lenin" Physics Institute imeni P. N. Lebedev. Spectroscopy of Laser Crystals with Ionic Structure] in Russian Vol 60, 1972 pp 3-30

VORON'KO, YU. K., OSIKO, V. V., PROKHOROV, A. M. and SHCHERBAKOV, I. A.

[Abstract] An investigation is made of the spectroscopic properties of extrinsic ionic crystals and the processes that take place in them during excitation of lasing action. These properties include the absorption and luminescence spectra, the kinetics of relaxation of stimulation of impurity ions, and processes such as nonradiative relaxation of excitation energy within the limits of a single excited ion and by transfer of this energy to other ions of the same kind or of different kinds, and processes of energy

migration in the excited crystal. The spectroscopic properties of laser crystals are related in turn to the crystal-chemical structure: symmetry and composition of the nearby environment of the working ion, type of bond, different kinds of structures with respect to atomic defects, nature of distribution of the working ions with respect to lattice sites. The paper deals with some results of studies at the interface between the areas of spectroscopy and crystal chemistry. The authors discuss the ways that the spectroscopic characteristics of laser crystals are influenced by the distribution of impurity ions of rare-earth elements with respect to centers of different structure. Methods are presented for analyzing the complex Stark structure of the absorption and luminescence spectra of trivalent rare-earth ions. Figures 23; references 34: 29 Russian, 5 Western.

USSR

UDC 621.378.33

#### COMPRESSED GAS LASERS

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA. MOSHCHNYYE LAZERY I LAZERNAYA PLAZMA [Transactions of the "Order of Lenin" Physics Institute imeni P. N. Lebedev. High-Power Lasers and Laser Plasma) in Russian Vol 85, 1976 pp 49-142

DANLIYCHEV, V. A., KERIMOV, O. M. and KOVSH, I. B.

[Abstract] The paper gives the results of theoretical and experimental studies of high-power compressed gas lasers. The electroionization method of stimulation is considered, and also pumping by an intense electron beam. Experimental data are presented on threshold and output characteristics, efficiency and amplification factor of CO<sub>2</sub> and CO lasers operating without cooling of the active medium. An examination is made of the outlook for using the electroionization method to excite lasers on electron transitions. Research results are given on compressed xenon and ArN<sub>2</sub> lasers with electron beam pumping in which lasing is achieved on electron transitions of molecules of Xe<sub>2</sub> (wavelength about 172 nm) and N<sub>2</sub> (wavelength about 357 nm). Consideration is given to the outlook for using compressed gas lasers in nuclear fusion reactors, for selective stimulation of chemical reactions and for machining operations. The article also contains an appendix presenting the theory of current flow through an ionized gas. Figures 79; references 118: 56 Russian, 62 Western.

USSR

UDC 621.378.325

MANDELSTAM-BRILLOUIN LASERS

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA.  
MOSHCHNYYE LAZERY I LAZERNAYA PLAZMA [Transactions of the "Order of Lenin"  
Physics Institute imeni P. N. Lebedev. High-Power Lasers and Laser Plasma]  
in Russian Vol 85, 1976 pp 3-48

RAGUL'SKIY, V. V.

[Abstract] An investigation is made of processes of stimulated emission and amplification of light in stimulated Mandelstam-Brillouin scattering [SMBS]. The article is based on SMBS research done by the quantum physics laboratory of the Lebedev Physics Institute in 1968-1973. An examination is made of the conditions necessary for efficient operation of SMBS lasers, amplifiers and modulators. Experimental and theoretical demonstrations are given of the feasibility of efficiency approaching 100% in conversion of the pumping radiation in lasers and amplifiers in the case of diffraction divergence of the lasing emission. Amplification factors and linewidths are determined in a number of compressed gases as a basis for choosing the optimum medium for Mandelstam-Brillouin lasers. An investigation is made of the influence that the spectral width of the stimulating radiation has on stimulated scattering. The possibility of wavefront inversion of the light scattered by SMBS with respect to the wavefront of the stimulating radiation is demonstrated. This effect can be used to compensate for phase distortions in the amplifying medium, enabling diffraction divergence of amplified radiation when the amplifier is of low optical quality. Figures 35; references 97: 44 Russian, 73 Western.

USSR

UDC 620.18:535:211

PRINCIPLES THAT GOVERN SHOCK WAVE FORMATION WHEN LASER EMISSION ACTS ON ABSORBING SOLIDS

Kiev PROBLEMY PROCHNOSTI in Russian No 6(108), Jun 78 pp 99-101 manuscript received 15 Aug 77

IVANOV, L. I., LITVINOVA, N. A. and YANUSHKEVICH, V. A., Moscow

[Abstract] An investigation is made of the spatial distribution of defects formed when stress waves produced by laser exposure propagate on the surface of absorbing solids. Single crystals of molybdenum 1 cm thick with surface area of about  $1.5 \text{ cm}^2$  were exposed to ruby laser pulses of  $5 \cdot 10^{-8}$  s in air

and also in water and ethanol at room temperature. The distribution of defects was determined from the concentration of etching pits revealed by successive electrolytic removal of layers. In addition to a high concentration of defects at the surface of the specimen, a maximum is observed at a depth of 10-45  $\mu\text{m}$ , with a tendency to approach the surface as the distance from the epicenter decreases. The maximum concentration of defects directly at the epicenter is observed at a depth of 0.65 mm. This pattern is observed at flux densities of  $10^8$ - $10^{10} \text{ W/cm}^2$  for metals and semiconductors that have speeds of sound in the solid state differing by a factor of 1.4, and densities differing by a factor of 4.4. Figures 2; references 10: 8 Russian, 2 Western.

USSR

#### CONCENTRATION OF LIGHT BY INVERTING ITS WAVE FRONT

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 27 No 11, 5 Jun 78 pp 619-622 manuscript received 13 Apr 78

PILIPETSKIY, N. F., POPOVICHEV, V. I. and RAGUL'SKIY, V. V., Institute of Problems in Mechanics, Academy of Sciences USSR

[Abstract] In problems of laser-driven fusion and propulsion, light must be concentrated on a small target. This paper reports the use of wave front inversion by stimulated scattering through  $180^\circ$  for concentration of laser radiation. A small flat target is exposed to ruby laser emission, and the light leaving the target is amplified by a ruby rod, backscattered by a quartz tube in liquid carbon disulfide, amplified once more, and the amplified inverted wave front then falls completely and precisely on the target regardless of its position in space or aberrations on the propagation path. In view of the nonselective nature of stimulated scattering, the proposed technique should be applicable to lasers on different wavelengths. It should also be possible to increase the energy and power of radiation by using different scattering media. Since wave front inversion can compensate only for distortions involving phase, the minimum target diameter is limited by diffraction. The authors thank Ya. B. Zel'dovich, A. Yu. Ishlinsky and V. B. Librovich for supporting the work, and Ye. P. Velikhov, S. D. Zakharov, O. Yu. Nosach and I. A. Fedulov for constructive criticism. Figures 2; references 7: 5 Russian, 2 Western.

USSR

UDC 535.313

ON THE FEASIBILITY OF USING STRUCTURES WITH OPEN POROSITY TO MAKE COOLED  
LASER MIRRORS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1169-  
1171 manuscript received 23 Mar 78

APOLLONOV, V. V., BARCHUKOV, A. I., BORODIN, V. I., BYSTROV, P. I., GONCHAROV,  
V. F., OSTROVSKAYA, L. M., PROKHOROV, A. M., RODIN, V. N., TRUSHIN, YE. V.,  
KHMICH, V. YU., TSYPIM, M. I., SHEVAKIN, YU. F. and SHUR, YA. SH., Physics  
Institute imeni P. N. Lebedev, Academy of Sciences USSR

[Abstract] The authors consider the feasibility of making a cooled laser reflector by using structures with open porosity to increase the threshold of optical destruction of the surface. It is shown that such structures can be made with a separating layer as thin as tens of  $\mu\text{m}$  between the radiation and the coolant. The theoretical analysis is based on the conditions of fluid flow and processes of heat transfer in the case of a porous layer consisting of spherical particles. It is found that the nature of flow depends most strongly on average pore size. For a surface with pore size of a few hundred  $\mu\text{m}$  and porosity of 0.6, using water as the coolant, flow is characteristically laminar under ordinary conditions. The coefficient of heat transfer is independent of pore size, but considerably dependent on porosity. Increasing porosity from 0.4 to 0.8 more than quadruples the heat transfer coefficient. The maximum heat flux that can be removed from a reflecting surface in convective flow for the practically attainable porosity of 0.7 is about  $200 \text{ W/cm}^2$ . A further increase in heat flux leads to boiling on the surface. Estimates show that in the mode of surface boiling of water, heat flux may reach several  $\text{kW/cm}^2$ . Under these conditions, the temperature of the reflecting surface with thin separating layer is almost entirely determined by the heat transfer on the inside surface, and with consideration of the saturation temperature corresponding to coolant pressure at the inlet to the structure, the temperature of the cooling surface is about  $200^\circ\text{C}$ . Experiments were done to determine thermal distortions of mirror surfaces based on structures with open porosity exposed to laser emission with a  $60 \mu\text{m}$  separating layer. The level of thermal deformation of a 50 mm mirror with steady-state heat flux of  $500 \text{ W/cm}^2$  was about  $0.35 \mu\text{m}$  for a laser wavelength of  $10.6 \mu\text{m}$ . The experiments showed that a porous mirror could handle a heat flux of about  $2.5 \text{ kW/cm}^2$  reliably. References 6: 2 Russian, 4 Western.

USSR

UDC 621.375.8

ELECTRIC-DISCHARGE EXCIMER LASERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1164-1166 manuscript received 30 Sep 77

BYCHKOV, YU. I., KOSTIN, M. N., TARASENKO, V. F. and FEDOROV, A. I., Institute of Optics of the Atmosphere, Siberian Department, Academy of Sciences USSR, Tomsk

[Abstract] The paper gives the results of a study of a laser based on XeCl\* molecules. Excitation of these molecules by a fast discharge gives a lasing energy of 21 mJ. It is shown that pulsed nitrogen laser systems can be used to achieve stimulated emission on molecules of XeF\*, KrF\* and XeCl\*. Curves are given for the emission energy as a function of composition and pressure of the mixture. Oscillograms of the radiation pulses are given. Emission of 21 mJ is achieved on He:Xe:CCl<sub>4</sub> = 750:12:1 at a wavelength of 308 nm, and 15 mJ on He:Xe:NF<sub>3</sub> = 100:1:1 at 350 nm in a discharge space of 100 x 1.8 x 0.3 cm. It is shown that chloroform is suitable as the halide carrier in lasers working in the pulse recurrence mode. Pulse duration in the XeCl laser is half the value for the other two lasers. Figures 3; references 10: 4 Russian, 6 Western.

USSR

UDC 621.373:533.915

PREIONIZATION OF GAS BY ELECTRODELESS CAPACITIVE PULSES IN LASERS OPERATING IN THE PULSE-RECURRENCE MODE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1157-1159 manuscript received 11 Sep 77

GENERALOV, N. A., ZIMAKOV, V. P., KOSYNKIN, V. D., RAYZER, YU. P. and ROYTENBURG, D. I., Institute of Problems in Mechanics, Academy of Sciences USSR, Moscow

[Abstract] The use of electron beams for preionizing the gas in high-pressure CO<sub>2</sub> lasers involves complicated equipment and provisions for x-ray shielding. In an effort to overcome these difficulties, breakdown pulses with a high recurrence rate have been used in cw lasers. In this paper, experiments are described in which such pulses are produced by an electrodeless capacitive method and used for preionization in high-pressure lasers operating at a high pulse recurrence rate. Volumetric discharge was achieved

at high pressure by using an auxiliary capacitive discharge. The delay between the capacitive and main volumetric discharges had to be maintained at an optimum value to avoid drifting of the discharge toward the upper or lower plate. Pulse recurrence rate was limited by the gas flowrate. In these experiments a recurrence rate of 10-15 Hz was optimum, but this could be increased by pumping the gas through the laser at a faster rate. It should be possible to use this comparatively simple method for preionization in lasers with a considerable energy input at atmospheric pressure. Figures 2; references 3 (Russian).

USSR

UDC 621.373.826.038.823

SPECTROSCOPIC INVESTIGATION OF THE GAS-DISCHARGE PULSE PLASMA OF A Cu + Ne LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1147-1151 manuscript received 7 Sep 77

GRIDNEV, A. G., GORBUNOVA, T. M., YELAYEV, V. F., YEVTSUSHENKO, G. S., OSIPOVA, N. V. and SOLDATOV, A. N.

[Abstract] The paper gives the results of an experimental study of luminescence on spectral lines of CuI, CuII, NeI and NeII based on an investigation of their absolute and relative intensities and the influence of spontaneous emission on the lasing mode. The intensities of spectral lines were registered with time scanning on a facility with photoelectric sensor, and the emission spectrum was produced on a monochromator. The converted signal from the photomultiplier output was sent to the input of a stroboscopic oscilloscope, and the current pulse taken from a Rogowski loop in the discharge tube power supply was sent to the other input of the oscilloscope. The time behavior of the spectral lines of copper and neon buffer gas was studied over a period of 400 ns from the beginning of the current pulse. The shape of the stimulated emission pulses was recorded by a coaxial photocell. The average lasing power was also recorded. Most of the lines reached maximum intensity within 50-70 ns, and superluminescence within 50-60 ns from the beginning of the current pulse. It is found that charge exchange, Penning discharge polarization and recombination to a considerable extent determine the population of metastable states  $4s^2 \ ^2D_{3/2,5/2}$ , i.e., the lower laser levels in the discharge afterglow. Thus these processes have a considerable influence on the pulse recurrence rate in lasers on self-limited transitions. It is pointed out that the influence of these processes on the operation of a copper vapor laser on a Cu+He mixture will be much stronger than in lasers of other types since copper and helium have a larger number of resonance states that take part in processes resulting in line amplification. Figures 3; references 6: 5 Russian, 1 Western.

USSR

UDC 621.373.826.038.823

FREE-WHEELING STIMULATED EMISSION OF A CO<sub>2</sub> GAS-DISCHARGE LASER IN THE NANOSECOND LIGHT PULSE RANGE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1141-1143 manuscript received 18 May 77

BARANOV, V. YU., BORISOV, V. M., KIRYUKHIN, YU. B., KOCHETOV, I. V., PEVGOV, V. G. and STEPANOV, YU. YU.

[Abstract] Experiments were done to determine the feasibility of achieving stimulated emission in a pulse with energy of the order of a joule in the nanosecond range in the free-running mode on a CO<sub>2</sub> laser. The experiments were based on a theoretical model including consideration of the populations in levels of the system 001<sup>1</sup>-02<sup>2</sup>0-0200-10<sup>0</sup>0-0310-11<sup>1</sup>0 and the average number of quanta in the vibrational mode  $\nu_2$  and in mode  $\nu_3$  of the CO<sub>2</sub> molecule. The theoretical results showed that a laser pulse of 5-15 ns duration with lasing efficiency of up to 10% should be possible with a cavity 15 cm long, energy input of 150 J· $\text{J}^{-1}\cdot\text{at}^{-1}$  over a time of about 100 ns when the working mixture is CO<sub>2</sub>:N<sub>2</sub>:He = 1:0.5:3 at pressures of 2-10 at. A fast discharge was ignited in a 1-cm interelectrode space with cross section of 2.5 x 40 cm. The power supply used a Marks oscillator charging a low-inductance capacitor to produce a current pulse with rise time of about 10-20 ns resulting in a current build-up rate of 10<sup>12</sup> A/s or more and peak current densities of about 100-200 A/cm<sup>2</sup>. The maximum E/p was reached before breakdown, and ranged from 15-17 kV/(cm·at) for the theoretical working mixture to 40-50 kV/(cm·at) for mixtures of CO<sub>2</sub> and air. The cavity was formed by a flat gold-plated mirror and a germanium plate with 50% reflectivity. Of the various mixtures tried, the theoretical one was optimum for minimum pulse duration. Pulse duration also depends on cavity length and transparency of the output mirror. With 8% lasing efficiency, 10 ns pulses were obtained. Figures 2; references 7: 4 Russian, 3 Western.

USSR

UDC 621.378.3

A MODULATION METHOD OF MEASURING THE SPATIAL CHARACTERISTICS OF LASER EMISSION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1130-1138  
manuscript received 24 Jun 77

GRIMBLATOV, V. M., BEKSHAYEV, A. YA. and KALUGIN, V. V., Odessa State University imeni I. I. Mechnikov

[Abstract] A theory is proposed for the modulation technique of measuring laser parameters in which the emission is passed through a spatial filter such as a slit and spatial modulation is accomplished by relative scanning of the beam and the slit. The theory is developed for arbitrary forms of the investigated distribution function and modulation parameters for the purpose of optimizing them to measure different spatial characteristics of laser radiation. Expressions are derived for the amplitude of the n-th harmonic as a function of slit size and scanning amplitude, and conditions for maximizing the fundamental waveform. An estimate of the attainable sensitivity of the method in measuring deviations of the volumetric radiation pattern of a laser beam gives a value of  $10^{-8}$  mm for the minimum measurable shift in the transverse direction when the output power of the laser is  $10^{-4}$  W, threshold power of noises in the photoreception device is  $10^{-12}$  W and the size of the spot in the plane of the photoreceiver is 0.5 mm. Experiments show that the sensitivity of the method for registration of the distribution function decreases with an increase in modulation parameters (width of the slit and scanning amplitude), which is in agreement with the theory. Experiments also confirm the theory on maximizing the fundamental. The experimentally observed sensitivity to transverse shift of the radiation pattern could be brought to the theoretical limit by noise optimization of the photoreceiver. Figures 5; references 20: 16 Russian, 4 Western.

USSR

UDC 535.5:621.371.24

THERMAL SELF-FOCUSING OF A LASER BEAM THAT HAS SPACE AND TIME NONHOMOGENEITY

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1119-1123  
manuscript received 8 Jun 77

YEROKHIN, A. I., MORACHEVSKIY, N. V. and FAYZULLOV, F. S., Physics Institute  
imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] The problem of compression of a laser beam by thermal self-focusing has been theoretically analyzed in previous research, but the theoretical estimates of the effect have been based on assumption of ideal energy distribution in the beam. Since the energy distribution in multimode laser beams shows pronounced space and time nonhomogeneities, the authors conduct experiments to determine how nonlinear refraction than arises when laser radiation interacts with transparent dielectrics influences the energy distribution at the focus of a lens. The radiation source was a neodymium laser operating in the free emission mode. It is found that nonlinear conversion produces energy distribution at the lens focus that is smooth and nearly gaussian. A mechanism is proposed to explain this effect as the result of modes of oscillation in the laser spectrum with low transverse indexes. Since these are high-Q (and therefore high-energy) modes, they are capable of heating up a narrow channel in the dielectric. The energy of radiation on other modes with higher transverse indexes flows into this channel, resulting in correction of energy distribution in the far zone. It is suggested that this self-focusing effect could be used for laser machining of materials. Figures 4; references 7 (Russian).

USSR

UDC 621.378.325:539.293.011

DYNAMICS OF SELF-STRESSING OF NEODYMIUM LASER RADIATION IN SEMICONDUCTORS  
OF THE A<sup>II</sup>B<sup>VI</sup> GROUP

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1095-1100  
manuscript received 24 Apr 77

BORSHCH, A. A., BRODIN, M. S. and KRUPA, N. N., Institute of Physics, Academy  
of Sciences UkrSSR, Kiev

[Abstract] Previous studies of self-stressing of ruby laser radiation in type A<sup>II</sup>B<sup>VI</sup> semiconductors have shown that self-stressing may show up with both self-focusing and self-defocusing of the laser beam, depending on the beam intensity and on the ratio between the width of the forbidden band of

the semiconductor and the energy of a laser quantum. Studies of the change in the index of refraction as a function of crystal temperature, geometry of laser beam propagation and width of the forbidden band of the semiconductors were interpreted in terms of the mechanisms of nonlinearity of the index of refraction in these semiconductors. In this paper a further investigation is made into the nature of nonlinearity of the index of refraction in  $\text{Al}_\text{II}\text{B}_\text{VI}$  semiconductors on the basis of the dynamics of self-stressing of neodymium laser emission, revealing the time changes in the index of refraction which yield additional information on nonlinearity mechanisms. It is shown that a positive change in  $n$  in the light wave field in the semiconductors almost instantly follows a change of light intensity in the laser monopulse, while relaxation of the negative nonlinear contribution to  $n$  correlates with the lifetime of nonequilibrium free carriers that arise as a result of two-photon absorption. It is also shown that the principal mechanism of nonlinearity of  $n$ , leading to self-focusing, is nonlinear polarizability of bound electrons, while nonequilibrium free carriers determine the nature of nonlinearity that leads to self-defocusing. Figures 5; references 5 (Russian).

USSR

UDC 535.232.65

RESONANT EMISSION ORIENTATION OF MOLECULAR OF MOLECULAR GAS, OPTICAL DETECTION, AND THEIR APPLICATION TO LASER SPECTROSCOPY

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1083-1089  
manuscript received 29 Jun 77

BAZAROV, YE. N., GERASIMOV, G. A., DERBOV, V. L., KOVNER, M. A. and POTAPOV, S. K., Institute of Radio Electronics, Academy of Sciences USSR, Moscow

[Abstract] A report to a session of the Science Council on Coherent and Nonlinear Optics, Moscow, February 1977, the third paper by these authors on optical detection in high-resolution molecular spectroscopy. Theoretical and experimental studies are done on the problem of resonant optical detection on allowed transitions of molecules in low-pressure gases. An examination is made of mechanisms responsible for additional permittivity and constant polarization in a gas under the action of resonant emission and a constant electric field. Resonant optical detection is observed in molecules of  $\text{OsO}_4$  and  $\text{SF}_6$  pumped by  $\text{CO}_2$  laser radiation. This type of optical detection can be used to record IR absorption spectra by a frequency-tunable laser since the resonant optical detection signal copies the absorption line contour. If a standing wave is used for pumping, a narrow dip will show up in the center of the spectral contour of the optical detection signal when the pressure is low enough (when the homogeneous width is much less than the

Doppler width), which is applicable to superhigh-resolution spectroscopy. Optical detection signals can be used to determine the concentrations of molecules in excited states, and to determine the dipole moments and polarabilities of the molecules in these states. Of particular interest is the mechanism of optical detection on Stark sublevels for studying orientation relaxation of molecules. Figures 3; references 17: 11 Russian, 6 Western.

USSR

UDC 621.039.66

DEPENDENCE OF THE SPECTRUM OF OXYGEN-LIKE IONS ON ELECTRON DENSITY IN A LASER PLASMA

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1077-1082  
manuscript received 1 Jun 77

VINOGRADOV, A. V., PEREGUDOV, G. V., RAGOZIN, YE. N., SKOBELEV, I. YU. and  
YUKOV, YE. A., Physics Institute imeni P. N. Lebedev, Academy of Sciences  
USSR, Moscow

[Abstract] The populations of excited states of oxygen-like ions (configuration  $2s^2 2p^4$ ) are calculated at temperatures and densities typical of a laser plasma, and the emission spectrum is studied in the wavelength range of 100-200 Å. Measurements are made of the relative intensities of the density-sensitive spectral lines that correspond to transitions between the configurations  $2s^2 2p^4$ ,  $2s2p^5$  and  $2p^6$ . The results are used to determine the density of a laser plasma from the relative intensities of lines of CaXIII and TiXV ions. The authors thank E. Ya. Kononov and U. I. Safronova for providing corrected probabilities of radiative transitions before publication, and also thank E. Ya. Kononov for discussion during the work. Figures 5; references 18: 14 Russian, 4 Western.

USSR

UDC 621.378.33+375.82

HYDROGEN HALIDE LASERS WITH TRANSFER OF VIBRATIONAL ENERGY FROM METASTABLE DIATOMIC MOLECULES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1048-1056  
manuscript received 26 May 77

IGOSHIN, V. I. and ORAYEVSKIY, A. N., Physics Institute imeni P. N. Lebedev,  
Academy of Sciences USSR, Moscow

[Abstract] The authors study the feasibility of achieving lasing action on diatomic molecules. It is shown that highly efficient coherent stimulated emission can be realized on hydrogen halide by accumulating vibrational energy on metastable molecules A and transferring a vibrational quantum from A to hydrogen halide B. The analysis is based on the  $H_2 + HF$  system, for which kinetic information is most complete. The main principles illustrated by this analysis can be readily extended to an arbitrary pair of a metastable diatomic molecule A and a hydrogen halide B. An examination is also made of the feasibility of making efficient electron beam-controlled lasers based on other binary mixtures of this type. The theory is applicable to vibrational-rotational transitions in HF, DF, HCl, DCl, HBr and DBr with transfer of vibrational energy from slow-relaxing diatomic molecules  $H_2$ , HD,  $D_2$ ,  $N_2$  and CO. Consideration is given to the principal factors that influence laser efficiency: the rotational quantum number J of radiative states, initial gas temperature, partial pressures of components and specific energy input. An estimate of the optimum parameter  $E/p$  gives a value of about 3 V/cm $\cdot$ mm Hg. It is concluded that under optimum working conditions the efficiency of lasers of this type may reach 40-50% for systems based on  $H_2 + HF$ , HD + HCl and  $D_2 + HBr$ , and 50-70% for lasers based on  $N_2 + DBr$  and CO + DBr without cooling of the working medium. To optimize the efficiency of energy input, it may be advisable to use combined mixtures of  $N_2 + CO + DBr + He$  (Ar) and  $N_2 + CO + DCl + He$  (Ar), where the carbon monoxide acts as an energy accumulator. To extend the range of emission wavelengths, mixtures could be used with several radiating molecules of hydrogen halides, e.g.,  $D_2 + HCl + HBr + He$  (Ar),  $N_2 + CO + DBr + DCl + He$  (Ar) and so on. To achieve the maximum lasing efficiencies, vibrational-rotational transitions must be utilized that have high quantum numbers J (of the order of 10 or higher) lying above the values that correspond to the maximum unsaturated gain. References 20: 8 Russian, 12 Western.

USSR

UDC 662.613+535.339+533.601

AMPLIFICATION FACTORS OF MULTICOMPONENT WORKING MEDIA IN A CO<sub>2</sub> GASDYNAMIC LASER OPERATING ON COMBUSTION PRODUCTS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1013-1018  
manuscript received 20 May 77

YEVTYUKHIN, N. V., GENICH, A. P., YUDANOV, A. A. and MANELIS, G. B., Institute of Chemical Physics, Academy of Sciences USSR, Moscow

[Abstract] An investigation is made of the optical gain of complex laser media with compositions equivalent to those of the combustion products of various fuels made up of atoms of C, H, O and N. The atomic percentages of the elements ( $\xi_i$ ) ranged over ratios  $\xi_C/\xi_O$  of the order of 1 or less,  $\xi_H/\xi_O$  of the order of 1 or less, and  $\xi_N = 0.6$ . It is found that each composition has its own optimum values of stagnation parameters for which optical gain is maximum. Lines of equal gain are plotted on triangular C-O-H composition diagrams for different temperature and pressure conditions. The results can be used for preliminary evaluation of the feasibility of making CO<sub>2</sub> gasdynamic lasers to operate on different fuel combustion products. Figures 3; references 14: 9 Russian, 5 Western.

USSR

UDC 621.378.826.038.823

A SEALED COOPER VAPOR LASER WITH LONG SERVICE LIFE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1000-1004  
manuscript received 18 May 77

BURMAKIN, V. A., deceased, YEVTYUNIN, A. N., Lesnoy, M. A. and BYLKIN, V. I.

[Abstract] Two of the main difficulties of developing reliable and durable copper vapor lasers are the high temperature of the discharge channel (1600°C) and the continuous diffusion drift of working material from the active zone toward the open ends of the channel. In addition to the problems resulting from these factors, solutions must be found for ensuring uniform distribution of the temperature lengthwise in the working channel, thermostatic control of the active element and development of a reliable pulse supply source. Solutions have been found for all these problems in the proposed self-heated copper vapor laser. The gas-discharge tube is of metal-glass construction with natural convective cooling. The windows of the ceramic discharge channel are made of optical glass with expansion coefficient matched to the glass of the end sections. The inert buffer gas is neon. The service life

of the laser is extended to 2000 hours by increasing the pressure of the buffer gas to 200-300 mm Hg instead of the 10-15 mm Hg that would give maximum output power. Calculations show that the increased pressure extends laser durability by a factor of about 20, which is considered adequate compensation for the 25-30% reduction in output power. The higher density of the buffer gas also retards diffusion flow of copper vapor and erosion products, resulting in slower coating of the end windows. The efficiency of the laser will be considerably improved by optimizing the power supply. Calculations show that improvements now being made on this problem should triple the output power. Figures 5; references 2: 1 Russian, 1 Western.

USSR

UDC 621.375.9:535

USING THE PRODUCTS OF ELECTROCHEMICAL REACTIONS IN THE ACTIVE MEDIUM OF DYE LASERS TO EXTEND THE TUNING RANGE OF STIMULATED EMISSION SPECTRA

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 986-994  
manuscript received 5 May 77

TOMIN, V. I., NEMKOVICH, N. A. and RUBINOV, A. N., Institute of Physics,  
Academy of Sciences BSSR, Minsk

[Abstract] The paper gives research results reported to the Eighth All-Union Conference on Coherent and Nonlinear Optics in Tbilisi, May 1976. A method is proposed for wide-band tuning of dye lasers in which ionic dye forms are electrochemically produced. The technique is based on the experimentally observed property of active media to form different modifications of molecules when an electric current is passed through them. The spectral, time, energy and angular characteristics of stimulated emission are observed with electrochemical action on various dye solutions. A pulsed nitrogen laser was used for pumping. It is shown that this technique can extend the bandwidth of stimulated emission in dye lasers by a factor of 1.5-2. The passage of the electric current has practically no effect on optical nonhomogeneity of the dye solution or on beam divergence. In some dye solutions, the electric current stabilizes the energy of the laser output. The electrochemical effect is completely reversible, tuning is immediate, and the method allows remote control of emission characteristics. Figures 5; references 15: 9 Russian, 6 Western.

USSR

UDC 535.375

WAVEFRONT REVERSAL ACCOMPANYING STIMULATED SCATTERING OF LIGHT IN A FOCUSED SPATIALLY NONHOMOGENEOUS PUMPING BEAM

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 973-985  
manuscript received 25 Mar 77

BARANOVA, N. B., ZEL'DOVICH, B. YA. and SHKUNOV, V. V., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] The theoretical model now accepted for wavefront reversal that accompanies stimulated scattering of light is limited to the case of a light guide exposed to pumping that is statistically uniform with respect to cross section. In this paper the authors propose a theory for a beam that is focused by a lens in an infinite medium. In this case the pumping beam has both fine-structure nonhomogeneity (and hence "gray" divergence), and a continuous amplitude and phase envelope. An equation is derived that describes amplification of the field component that reproduces the pumping wave. This equation is solved for excitation by noises of spontaneous emission in the predetermined pumping field approximation. The scattered wave is localized in a narrow paraxial region as compared with the pumping wave. In contrast to scattering in a light guide, pumping reproduction is incomplete and depends on the ratio between "gray" divergence and diffraction divergence. The theoretical predictions are compared with experimental results on wavefront reversal accompanying stimulated Mandelstam-Brillouin and Raman scattering. It is shown that pumping saturation effects cannot be disregarded in analyzing wavefront reversal for scattering of light in focused spatially nonhomogeneous beams. The authors thank N. A. Mel'nikov, N. F. Pilipetskiy and V. V. Ragul'skiy for discussing the experiments. References 20: 19 Russian, 1 Western.

USSR

UDC 621.378.325.2

PROPERTIES OF RING LASERS THAT CONTAIN OPTICAL ELEMENTS WITH MAGNETIC CIRCULAR DICHROISM

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 965-972  
manuscript received 27 Dec 76

VOYTOVICH, A. P. and SARDYKO, V. I., Institute of Physics, Academy of Sciences BSSR, Minsk

[Abstract] A ring laser is described with the distinguishing feature of using elements with magnetic circular dichroism, and the properties of such a laser are investigated. Initial frequency splitting can be realized in the proposed device by using natural optical activity. In comparison with methods based on the Faraday effect, the magnitude of splitting of natural frequencies of a passive cavity for opposite directions is more stable, and is not subject to the influence of magnetic fields. It is shown that in some cases the zero drift due to instability of the dispersion characteristics of the active medium can be considerably reduced. Such a ring laser can also be used for measuring natural optical activity of materials. An investigation is made of the influence that imperfections in the elements and instabilities in different parameters of these lasers have on the stability of frequency splitting resulting from natural optical activity. The authors thank N. A. Borisevich for discussing the work. Figures 2; references 11: 7 Russian, 4 Western.

USSR

UDC 621.378.325

ON THE PROBLEM OF MODE LOCKING IN A SOLID-STATE RING LASER

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 4, Jun 78 pp 1318-1320 manuscript received 12 Jan 77

LARIONTSEV, YE. G. and SERKIN, V. N., Scientific Research Institute of Nuclear Physics Affiliated with Moscow State University imeni M. V. Lomonosov

[Abstract] The feasibility of stable mode locking in a solid-state ring laser is considered on the basis of numerical solution of a system of differential-difference equations that describe stimulated emission in a traveling-wave laser in terms of the field amplitude, polarization and inverse population density. Mode locking is achieved by injection of a short light pulse during steady-state single-mode lasing, or at the instant of development of stimulated emission. It is shown that with increasing cavity length and pumping beyond the threshold level the percentage modulation increases

and a series of short intense pulses is formed. Calculations showed that in the region of instability of steady-state single-mode lasing, even when pumping exceeds the threshold level by a factor of the order of  $10^2$ , steady-state lasing arises with insignificant percentage modulation of the emission intensity. Figures 2; references 11: 4 Russian, 7 Western.

USSR

UDC 621.378.325

### A PERIODIC-PULSE CO<sub>2</sub> LASER

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 5, May 78 pp 1039-1040 manuscript received 5 Mar 77

BARANOV, V. YU., DROKOV, G. F., KAZAKOV, S. A., MEZHEVOV, V. S. and NIZ'YEV, V. G.

[Abstract] A periodic-pulse CO<sub>2</sub> laser is developed with closed circulation of the working mixture. The gas loop includes a rotary installation for transferring the gas mixture at a rate of 300 l/s, two coolers based on KFB-3 air heaters, a gas channel and a discharge chamber. Guide vanes are installed in the chamber preceding the electrode system to equalize the distribution of the gas flow. The velocity of the gas flow in the discharge region is 30 m/s. Preliminary UV irradiation is used in the electrode system. Partial makeup feed is provided for the gas mixture to enable many hours of continuous operation. The gas mixture is CO<sub>2</sub>:N<sub>2</sub>:He = 1:1:5. Provisions are made for interchangeable stable, unstable and selective cavities. The selective cavity with diffraction grating provides a tuning range of 9.2-10.8 μm. Beam divergence in this case is 10<sup>-3</sup> radian. In the case of the unstable telescopic cavity, beam divergence is close to the diffraction value of about 0.5·10<sup>-3</sup> radian. Experiments showed that the specific energy input is 250 J/l at with efficiency of up to 10%. Preliminary UV irradiation ensures uniform distribution of laser emission with respect to beam cross section. A pulse shape suitable for separating isotopes is produced by eliminating the nitrogen from the gas mixture and using a ratio of CO<sub>2</sub>:He = 1:5. The authors thank S. V. Pigul'skiy for assistance in making the laser. Figures 3; references 5: 1 Russian, 4 Western.

USSR

UDC 539.23

USING A CO<sub>2</sub> FREQUENCY LASER TO SPUTTER METAL, SEMICONDUCTOR AND OXIDE FILMS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 5, May 78 pp  
991-996 manuscript received 29 Dec 76

BYKOVSKIY, YU. A., BOYAKOV, V. M., GALOCHKIN, V. T., MOLCHANOV, A. S.,  
NIKOLAYEV, I. N. and ORQYEVSKIY, A. N., Moscow Engineering Physics Institute  
imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] A CO<sub>2</sub> TEA frequency laser with controllable pulse recurrence rate was used to sputter thin films of metals (Cd, Bi, Ag, In, Sn, Cr, Dy, Gd, Fe, Zr, Hf and Ti), semiconductors (Te, Ge, Si, ZnSe, ZnS, CdS, InSb, GaP and GaAs) and oxides (SiO<sub>2</sub> and ZrO<sub>2</sub>). Maximum pulse energy reached 15 J. The target was located in a vacuum of about 10<sup>-4</sup> mm Hg. The substrate was NaCl. Deposition rate was about 10<sup>6</sup> Å/s. Film properties were studied by electron diffraction, the Mössbauer effect and optical absorption. At intensities of greater than 3·10<sup>7</sup> W/cm<sup>2</sup> the processes of vaporization and condensation of films take place similarly to solid-state laser sputtering. The CO<sub>2</sub> frequency laser has a considerable advantage in ability to achieve effective vaporization of oxides. The difficulties associated with disruption of the stoichiometric composition of some oxide films can apparently be overcome by proper tailoring of the laser pulse and selection of the degree of vacuum and the atmosphere in which sputtering is done. It is suggested that laser-sputtered thin films of Ge, ZnS and SiO<sub>2</sub> could be used as antihygrosopic coatings for optical instruments. Figures 5; references 9: 3 Russian, 6 Western.

USSR

UDC 621.378.325

ANALYSIS OF THE CHARACTERISTICS OF A STEADY-STATE ELECTRIC-DISCHARGE CO  
LASER

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 5, May 78 pp  
977-982 manuscript received 21 Apr 77

KONEV, YU. B., KOCHETOV, I. V. and PEVGOV, G. V., Moscow Physicotechnical  
Institute

[Abstract] The authors analyze the available experimental and theoretical literature on the rate constants of kinetic processes in the gas mixture of a CO laser, on the effective cross sections of elastic and inelastic processes of collisions between electrons and the gas molecules of the mixture, and on the probabilities and linewidths of radiative transitions. This material is

is used to calculate the distribution functions of CO molecules with respect to vibrational levels, the amplification factors on different vibrational-rotational transitions and the emission spectra of CO gas-discharge lasers in the steady state. A comparison of the calculated parameters with experimental data shows good agreement, enabling development of a kinetic model of CO lasers in the steady and quasi-steady states that is suitable for quantitative predictions of laser parameters. On the basis of this model, an investigation is made of the influence that temperature and pumping power have on the characteristics of an electric-discharge CO laser operating in the steady state. The calculation was based on solution of a system of balance equations for the populations of 50 vibrational levels of the CO molecule with consideration of vibrational-vibrational exchange, vibrational-translational relaxation, stimulated and spontaneous emission, pumping of vibrational levels of the CO molecule by electron impact, and losses due to relaxation of vibrationally excited molecules on the walls of the tube. The authors thank A. N. Starostin and I. V. Novobrantsev for discussing the results. Figures 6; references 18: 2 Russian, 16 Western.

USSR

UDC 533.95.082.5:621.039.66

POPULATION INVERSION OF HELIUM LEVELS WITH SUPERSONIC EXPANSION OF PLASMA

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 5, May 78 pp 949-955 manuscript received 6 Jun 77

ZHINZHIKOV, G. M., LUK'YANOV, G. A., NAZAROV, V. V. and PAVLOVA, N. O.,  
Leningrad Mechanics Institute

[Abstract] Experiments were done to determine the influence that gasdynamic and design parameters of the plasma source have on population inversion of He I levels with principal quantum numbers of 4 and 3 as a helium plasma expands into a low-pressure atmosphere from circular and flat nozzles. An electrothermal plasma source was used with gas-swirling arc stabilizer. Stagnation temperatures were varied from 3000 to 16,000 K, stagnation pressure range was  $(0.5-2) \cdot 10^4 \text{ N/m}^2$ , and the plasma jet was discharged into a chamber with steady-state evacuation holding the pressure at  $(0.5-5) \cdot 10^2 \text{ N/m}^2$ . In an axisymmetric jet, population inversion takes place at a certain distance from the nozzle tip, while in planar cases, population inversion is realized right at the tip of the nozzle slit. Experimental verification confirms the hypothesis of the recombination mechanism of population of He I levels under the given conditions, and the feasibility of getting an inverse population by a differential between the rates of impact deactivation of levels. The population inversion of levels achieved in the experiments corresponds to amplification coefficients of the order of  $0.1 \text{ m}^{-1}$ . The diffusion

of nitrogen into the jet from the ambient medium reduced the population inversion. Amplification factors of the order of 2% per pass can be achieved by using a slit nozzle with longitudinal feed of the plasma into the fore-chamber. Figures 7; references 7: 6 Russian, 1 Western.

USSR

UDC 621.378.33

GAS LASERS WITH WIDE BAND OPTICAL PUMPING (A REVIEW)

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 6, Jun 78 pp 1189-1220

MIKHEYEV, L. D.

[Abstract] This review analyzes new mechanisms of excitation of laser generation, achieved as a result of further development of methods of optical pumping. In addition to photodissociation, in which the electron-excited products are formed as the light is absorbed, the review covers the method of creation of a population inversion by secondary chemical reactions accompanying photodissociation, and the principle of direct optical excitation in allowed transitions of molecules in the gas phase. The search for new mechanisms of population inversion in the gas phase by optical excitation is of great practical significance, since it allows expansion of the spectral range of laser radiation with optical pumping by a strong point discharge, with movement, in particular, into the visible and UV areas of the spectrum, as well as increases in the efficiency of lasers of this type. Figures 20; references 87: 43 Russian, 44 Western.

USSR

SUBMILLIMETER LASER RADIATION ON TRANSITIONS BETWEEN LEVELS OF FREE EXCITONS  
IN A CRYSTAL

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 20 No 6, Jun 78 pp 1886-1888  
manuscript received 20 Jun 77

VLASOV, G. K., KALENKOV, S. G. and KUPCHENKO, G. A., Moscow Institute of  
Physics and Technology

[Abstract] It is experimentally confirmed that population inversion can be achieved in a CdS crystal at room temperature, leading to submillimeter laser action. The experiment was performed using pure, defect-free CdS crystals grown from the gas phase, excited by the radiation of a nitrogen laser with a peak power of not over 2 kW. Typical crystal sizes were  $0.1 \times 0.5 \times 3 \cdot 10^{-3} \text{ cm}^3$ . The pumping threshold is about 1.2 kW for crystals of this size and composition. The radiation spectrum in each lobe consists of chaotically modulated narrow lines (modes) in the 5280-5300 Å band. Figures 2; references 4: 3 Russian, 1 Western.

USSR

UDC 621.373.826.038.825.2

A RAMAN LASER WITH LIGHT-GUIDE CAVITY

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 6, Jun 78 pp 1305-1309  
manuscript received 4 Jul 77

DIANOV, YE. M., ISAYEV, S. K., KORNIYENKO, L. S., KRAVTSOV, N. V. and FIRSOV, V. V., Institute of Physics, imeni P. N. Lebedev, Academy of Sciences USSR; Moscow State University imeni M. V. Lomonosov

[Abstract] Experimental results are presented from a study of Raman-effect radiation in a YAG-Nd<sup>3+</sup> laser, the resonator of which contains a section of a multimode light guide based on quartz glass with low losses. Analysis of the oscilograms produced shows that as generation of the primary and Stokes radiation develops, two qualitatively different stages can be differentiated. The first stage corresponds to the beginning of the generation excursion, while in the second generation reaches the quasi-stable level. The laser, essentially a combination of 2 interacting lasers, is particularly promising for light guide communication lines. Figures 3; references 8: 4 Russian, 4 Western.

USSR

UDC 621.378.32

FREQUENCY DEGENERATION OF MODES IN A CONTINUOUS SOLID-STATE LASER WITH A PLANE-SPHERICAL RESONATOR

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 6, Jun 78 pp 1244-1247  
manuscript received 19 Apr 77

KUSHNIR, V. R. and SHOKIN, A. A.

[Abstract] A study is made of the influence of the configuration of a resonator and distortions of the thermally induced lens of its active element on the radiation power output achieved. The authors introduce the dimensionless parameters  $c=1/(R-1)$ ,  $y = 1/f$ , where  $f$  is the focal length of the internal lens located at distance  $l$  from a spherical mirror with radius of curvature  $R$  and at distance  $Kl$  ( $K > 0$ ) from a flat mirror. It is determined that the greatest drop in output power occurs in resonators with  $y = 1$ ,  $c = -1 + 1/K$  and  $y = 1 + 1/K$ ,  $c = -1 - 1/K$ . These resonators can be used to suppress transverse high order modes, but should be avoided if high multimode radiation power is required. Figures 5; references 3: 1 Russian, 2 Western.

USSR

UDC 621.3.038.8+535.232.1

SPECTRAL CHARACTERISTICS OF PREIONIZATION SOURCES OF CO<sub>2</sub> LASERS IN THE VACUUM ULTRAVIOLET RANGE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 6, Jun 78 pp 1221-1229  
manuscript received 14 Jul 77

ZAROSLOV, D. YU., KARLOV, N. V., KUZ'MIN, G. P. and NIKIFOROV, S. M., Institute of Physics imeni P. M. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] Spectral studies were performed with a vacuum monochromator type VM-1, using a spherically concave diffraction grating with 1200 lines per mm, radius of curvature 500 mm, pressure  $10^{-2}$  mm Hg, comparing the radiation spectrum of spark and creep discharges in the vacuum ultraviolet range. It is shown that a creep discharge can serve as an effective source of UV radiation in the 115-200 nm range, important for the preionization medium of a CO<sub>2</sub> laser. The advantage of such a discharge over a spark is not only the possibility of adjusting the spectrum by selecting the dielectric material, but also the possibility of arranging the discharge plasma more nearly optimally for pumping of the laser. The radiation spectrum of the creep discharge depends on the polarity of the power pulse, which must be considered in designing CO<sub>2</sub> lasers using creepage pumping. Figures 3; references 16: 9 Russian, 7 Western.

USSR

UDC 621.378.35

SPATIAL DISTRIBUTION AND MODES OF LASER EMISSION IN  $Zn_xCd_{1-x}S$  SINGLE CRYSTALS WITH OPTICAL ONE-PHOTON EXCITATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 6, Jun 78 pp 1272-1278  
manuscript received 11 Jul 77

BRODIN, M. S., VITRIKHOVSKIY, N. I., KIPEN', A. A., SHEVEL', S. G. and YANISHEVSKIY, N. I., Institute of Physics, Academy of Sciences, Ukrainian SSR; Institute of Semiconductors, Academy of Sciences Ukrainian SSR, Kiev

[Abstract] A study was performed of the spatial characteristics of lasing in mixed  $Zn_xCd_{1-x}S$  single crystals, and it was found that the model of a simple "Fabry-Perot resonator," i.e., an inverse layer on the excited surface of the crystal, the ends of which act as 2 mirrors, commonly used in the interpretation of the spectral properties of generation, does not provide a satisfactory explanation of the results of the experiments. The results are discussed and a possible interpretation given, based on a model of the rectangular dielectric resonator as a "box." The authors believe that the results produced are not related to any particular peculiarities of the objects studied, but rather are general in nature, extending to other crystals. The physical mechanism of amplification will be the subject of a later study. Figures 6; references 11: 6 Russian, 5 Western.

USSR

UDC 621.373.826.038.825.4

VARIBAND STRUCTURES IN SEMICONDUCTOR LASERS WITH ELECTRON EXCITATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 6, Jun 78 pp 1310-1317  
manuscript received 5 Jul 77

BOGDANKEVICH, O. V., BORISOV, N. A., BRYUNETKIN, B. A., DARZNEK, S. A. and PEVTSOV, V. F., All-Union Scientific Research Institute of the Metrologic Service, Moscow

[Abstract] Two types of variband structures are studied: in the form of a potential well and the variband structures proper. The distribution of active particles and effectiveness of collection of charge carriers in the structures are theoretically analyzed for the case of excitation of the semiconductors by an electron beam. It is demonstrated that these structures allow the lasing threshold to be decreased by almost an order of magnitude, with a particle collection efficiency of up to 100%. Figures 4; references 8: 7 Russian, 1 Western.

USSR

UDC 535.95

EXPERIMENTAL STUDY OF SPONTANEOUS MAGNETIC FIELDS IN A LASER PLASMA

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 6, Jun 78 pp 1230-1236  
manuscript received 5 May 77; after revision 27 Dec 77

MOTYLEV, S. L. and PASHININ, P. P., Institute of Physics imeni P. N. Lebedev,  
Academy of Sciences USSR, Moscow

[Abstract] An earlier work recorded two components of the spontaneous magnetic field in a laser plasma, one of which with any R (distance between center of focal spot and center of magnetic transducer) appears simultaneously with the arrival of the laser pulse at the target, while the maximum of the other component is delayed, increasing with increasing R. This experimental work is a continuation of the earlier work, and is intended to clarify the time and space characteristics of spontaneous magnetic fields under various conditions. In contrast to the earlier work, dielectric targets are used. The results agree qualitatively with the concept of a double-layer emf in the vicinity of the laser plasma, related to a system of closed currents passing through the laser plasma and the residual gas plasma. Figures 6; references 17: 9 Russian, 8 Western.

USSR

UDC 621.373.826.038.823

A PHOTOIONIZATION CO<sub>2</sub> LASER WITH AN ENERGY OF 300 J

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 6, Jun 78 pp 1381-1384  
manuscript received 23 Nov 77

ANAN'YEV, YU. A., GORYACHKIN, D. A., IRTUGANOV, V. M., KALININ, V. P.,  
PASHKOV, O. I. and SOLOV'YEV, V. A.

[Abstract] A report is presented on the production of an energy of 60 J/  
(l·atm) in a CO<sub>2</sub> photoionization laser with an active volume of 5 l. The  
energy expended in preionization in all experiments was 640 J, the primary  
discharge being delayed relative to the preionization pulse by 2 µs. The  
source of the primary discharge was a 2-stage Marx generator with inductance  
of the discharge circuit not over 0.5 µH. The peak voltage in the pulse was  
varied from 100 to 180 kV. The energy density in the radiation created by  
the laser is near 10 J/cm<sup>2</sup>, the theoretical maximum, with a beam energy in  
the near zone of 27 cm<sup>2</sup>. Figures 3; references 6: 2 Russian, 4 Western.

USSR

UDC 535.373.2:543.42:621.375.826

INFLUENCE OF NONCORRELATED, NONHOMOGENEOUS SPREAD OF THE 1.06  $\mu\text{m}$  BAND OF Nd<sup>3+</sup> IONS ON THE LASER PROPERTIES OF NEODYMIUM GLASS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 6, Jun 78 pp 1375-1379  
manuscript received 2 Nov 77

NIKITIN, V. I., SOSKIN, M. S. and KHIZHNYAK, A. I., Institute of Physics,  
Academy of Sciences Ukrainian SSR, Kiev

[Abstract] Two earlier works by the same authors used the method of an induced drop in luminescence to show that with inhomogeneous broadening of the 1.06  $\mu\text{m}$  band of Nd<sup>3+</sup> ions in glass, the correlation between the various Stark components is disrupted. Processing of the experimental results indicates that the contour of the induced luminescence drop (difference between luminescence contours before and after excitation of a giant pulse) contains a peak and a pedestal; the width of the peak was used to determine the homogeneous width of the Stark components and its variation with temperature. A model example was used to demonstrate that a quasi-equilibrium luminescence drop appears upon induced radiation. This article discusses this aspect of the problem in greater detail. The results indicate that the disruption in correlation between the Stark components upon heterogeneous broadening of the operating band of luminescence has a significant influence on all laser characteristics. Figures 3; references 6 (Russian).

USSR

UDC 621.378:535.211:551.51

NUMERICAL AND EXPERIMENTAL MODELING OF THERMAL SELF-STRESS OF LASER BEAMS ALONG A PATH WITH VARIABLE SPEED OF MOTION OF THE PROPAGATION MEDIUM

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 6, Jun 78 pp 1341-1347  
manuscript received 8 Jun 77

AGROVSKIY, B. S., VOROB'YEV, V. V., KALLISTRATOVA, M. A. and SHEMETOV, V. V., Institute of Atmospheric Physics, Academy of Sciences USSR, Moscow

[Abstract] A study is presented of the influence of regular change in the direction of the transverse component of wind speed on nonlinear thermal effects such as defocusing and nonlinear refraction as a laser beam propagates through moving air. The most significant differences from propagation in a homogeneous medium (moving at a constant speed along the path of the radiation) are experienced when the transverse component of wind speed in one section of the path is perpendicular to the velocity component in other sectors. The study allows estimates to be made of the effects for simple

atmospheric situations of propagation, when the path can be arbitrarily divided into two sectors moving at different speeds. Some general conclusions can be drawn for more general cases, but these conclusions are correct only when the primary mechanism of heat transfer is forced convection, i.e., the speed of movement of the medium relative to the beam does not drop to zero over the propagation path. Figures 6; references 8: 1 Russian, 7 Western.

USSR

UDC 535.334:621.375.8

COHERENT RADIATION OF SINGLE-FREQUENCY INJECTION LASERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 6, Jun 78 pp 1384-1386  
manuscript received 25 Nov 77

ANNENKOV, V. I., MIRONOV, YU. M., MOLOCHEV, V. I. and SEMENOV, A. S., Institute of Physics imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] Results are presented from studies of the coherent characteristics of a new batch of single-channel injection lasers. The laser diodes were made so that the active area of the diode is enclosed between two high-resistance layers of gallium arsenide, which limit the leakage of the injection current outside the active area and form an optical wave guide due to the jump in permittivity at the boundaries of the active area. Lasers with an active area width of 7-10  $\mu\text{m}$  were used, operating at 80 K in the continuous mode. Figures 3; tables 1; references 3: 2 Russian, 1 Western.

USSR

UDC 621.373:535

ESTIMATE OF THE ACCURACY OF A LASER DOPPLER VELOCIMETER

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 44 No 6, Jun 78 pp 1153-1156 manuscript received 19 Oct 77

LUKIN, I. P.

[Abstract] Laser Doppler velocimeters have been widely used in recent years, particularly for measurement of atmospheric turbulence. However, since one significant aspect of such systems is the mutual coherence of the sources, and propagation through a turbulent atmosphere introduces the greatest distortion to this very coherence, the problem arises of the error in velocity measurement introduced by the turbulence itself. This article addresses

this question, as well as the error introduced by fluctuations in the speed of the scattering atmospheric elements. An analytic expression is produced, relating the error in measurement of velocity to the geometric parameters of the velocimeter and the turbulence of the atmosphere. It is noted that the error introduced by turbulence is slight under laboratory conditions and over short path lengths (less than about 10 m), but significant for propagation through the near-earth atmospheric layer over longer distances ( $100 \text{ m}^{-1} \text{ km}$ ). These cases, therefore, require that the influence of atmospheric turbulence be considered, along with other distorting factors. Figure 1; references 7 (Russian).

USSR

UDC 621.373:535

THE POSSIBILITY OF CREATION OF A LASER BASED ON VIBRATIONAL-ROTATIONAL TRANSITIONS OF THE HD MOLECULE

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 44 No 6, Jun 78 pp 1190-1192 manuscript received 20 Nov 75; in final form, 4 Jan 78

YEVDOKIMOV, YU. B.

[Abstract] An estimate is presented of the gain achieved on the vibrational-rotational transitions of the HD molecule. It is concluded that the HD molecule is quite probably suitable for lasing at a wavelength of  $3-4 \mu\text{m}$ . It seems possible to achieve a gain on the order of  $10^{-3}\text{cm}^{-1}$ , extending into the shorter-wave area. Figures 2; references 6: 2 Russian, 4 Western.

USSR

UDC 535.34:621.373:535

ATTENUATION OF THE RADIATION OF A CHEMICAL HF LASER IN THE 2.7-3.3  $\mu\text{m}$  BAND IN THE ATMOSPHERE

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 44 No 6, Jun 78 pp 1192-1194 manuscript received 19 Nov 76; in final form 7 Dec 77

BANAKH, G. F., VOYTSEKHOVSKAYA, O. K. and IPPOLITO, I. I.

[Abstract] In order to estimate the transmission of the radiation of an HF laser in the atmosphere, the absorption of its radiation by water vapor and carbon dioxide was estimated, these being the primary absorbing components of the atmosphere in this wave band. The transmission factors are found to be comparable for HF and  $\text{CO}_2$  lasers. Tables 2; references 18: 5 Russian, 13 Western.

USSR

UDC 621.378.3

HYDROACOUSTIC EXCITATION OF THE ACTIVE MEDIUM OF LIQUID LASERS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 28 No 6, Jun 78 pp 984-991 manuscript received 13 Dec 76

GONDRA, A. D. and KOZLOV, N. A.

[Abstract] Hydroacoustical perturbations of a resonator have been detected interferometrically and on the basis of the agreement of the characteristic time of perturbation of lasing with the period of low-frequency acoustic oscillations in a cuvette. This work calculates the hydroacoustic and thermo-optical distortions of a resonator jointly and estimates their relative value during various periods of the pumping pulse. Hydroacoustic perturbation is manifested as a delay in the development of perturbations in the cuvette, and may be so great that it changes the nature of the induced lens. During the initial period of the pulse, the hydroacoustic and thermo-optical perturbations partially compensate each other, which may also affect the thermo-optical lens formation. Figures 3; references 12: 9 Russian, 3 Western.

USSR

UDC 533.9.02

PARAMETRIC RELATIONS PERTAINING TO A STEADY CO-LASER

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 241 No 1, 1978 pp 76-79  
manuscript received 12 Jul 77

ZHDANOK, S. A., KOCHETOV, I. V., NAPARTOVICH, A. P., NOVOBRANTSEV, I. V., PEVGOV, V. G., and STAROSTIN, A. N., Scientific Research Institute of Nuclear Physics, Moscow State University imeni M. V. Lomonosov

[Abstract] Parametric relations for a steady CO-laser are constructed both analytically, on the basis of the continuous quasi-resonance approximation for the distribution of an anharmonic molecule, and by numerical solution of the complete system of equations. Gain data obtained by both methods are found to be sufficiently close so that the analytical theory can be used for calculating the laser efficiency as a function of the threshold gain and other parametric relations such as the "vibration" temperature as a function of the gas temperature. The analytical theory is thus also accurate enough for the description of experiments. The paper was presented on 12 Jul 77 by academician Ye. P. Velikhov. Figures 3; references 11: 6 Russian, 5 Western.

USSR

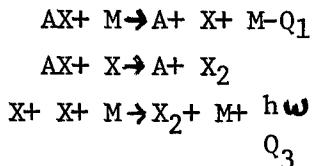
UDC 621.378.335

THEORY OF A PHOTORECOMBINATION LASER THERMALLY TRIGGERED BEHIND THE FRONT  
OF A SHOCK WAVE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 241 No 1, 1978 pp 80-83  
manuscript received 27 Jun 77

PEKAR, S. I., academician, IZMAYLOV, I. A., KOCHELAP, V. A., and KUKIBNYY,  
YU. A., Institute of Semiconductors, Academy of Sciences of the Ukrainian  
SSR, Kiev

[Abstract] The feasibility of a chemical photorecombination laser triggered by a sudden large temperature rise behind the front of a shock wave depends on overcoming several problems in the parallel reaction channels, namely the presence of light absorbing and products, the complexity of effecting an inversion, and the very narrow inversion band. The process involving a molecule AX in an inert gas M is analyzed here in terms of three reactions:



Calculations based on the equations of one-dimensional gas dynamics and chemical kinetics indicate that a low thermal activation energy and a high dissociation rate of the reactant molecules but a low rate of parasitic thermal  $\text{AX} + \text{X} \rightarrow \text{A} + \text{X}_2$  reactions are most favorable. The laser reaction can be optimized, by proper initial gas pressure, dilution, and stream velocity so as to simultaneously yield a population inversion and a high radical concentration. Figures 3; references 12: 11 Russian, 1 Western.

USSR

UDC 621.378.3

AN InSb-LASER WITH TWO-PHOTON PUMPING FROM A CO<sub>2</sub>-LASER

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 240 No 6, 1978 pp 1336-1339  
manuscript received 10 Jan 78

MYL'NIKOV, G. D., SOBOLENKO, D. N., and SHCHERLYKIN, YU. V., Institute of  
Atomic Energy imeni I. V. Kuratov, Moscow

[Abstract] The smallness of the effective mass of electrons in InSb makes it possible to vary the width of the energy gap with a magnetic field and thus to use this semiconductor material as an infrared laser source with continuous tuning. A study was made to determine the effects associated with two-photon absorption of CO<sub>2</sub>-laser radiation and thus the feasibility of optimizing the design parameters of an InSb-laser. The pumping source in this experiment included a CO<sub>2</sub> pulse laser and a diffraction grating as the exit reflector, specimens of InSb crystals were placed in a helium cryostat, and their temperature was varied from 15 to 80 K. Laser emission at the  $\lambda \approx 5.3$   $\mu\text{m}$  wavelength was obtained only up to 50 K, with the charge concentration in InSb within the  $10^{13}$ - $10^{16}$   $\text{cm}^{-3}$  range. Measurements of the pumping radiation intensity before and behind an InSb crystal have revealed a limiting effect, namely that the output intensity increases nonlinearly with the input intensity until, beyond some critical level, it remains almost constant with further increase in the input intensity. A pumping power of about  $10^5$  W/cm<sup>2</sup> was found to be the threshold for recombination radiation from an InSb-laser, this radiation also being found to be elliptically polarized. In order to explain the limiting effect, linear absorption of CO<sub>2</sub>-laser radiation by free charge carriers in InSb and nonlinear two-photon absorption are analyzed here theoretically on the basis of two differential equations describing the variation of radiation intensity inside a crystal. Calculations yield a critical intensity of about  $4 \cdot 10^4$  W/cm<sup>2</sup> for a crystal of L= 0.5 cm length, which agrees closely with the experimental data. According to the results, the optimum crystal length of approximately 0.1 cm corresponds to an output intensity equal to the threshold pumping intensity. An InSb-laser with an output power of at least 1 W is thus feasible. The authors thank V. A. Roslyakov and A. N. Starostin for the discussion. The paper was presented on 24 Feb 78 by academician Ye. P. Velikhov. Figures 3; references 8: 3 Russian, 5 Western.

USSR

UDC 621.373.853.08

A SUBMILLIMETER LASER WITH OPTICAL PUMPING OF NH<sub>3</sub>, CH<sub>3</sub>F, CH<sub>3</sub>I, AND D<sub>2</sub>O MOLECULES

Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian Vol 23 No 6, Jun 78 pp 1015-1017 manuscript received 30 Aug 77; after revision 2 Dec 77

MANITA, O. F., Khar'kov State University imeni A. M. Gorkiy

[Abstract] An experimental study was done to establish the feasibility and the performance characteristics of a submillimeter pulse laser with optical pumping of NH<sub>3</sub>, CH<sub>3</sub>F, CH<sub>3</sub>I, and D<sub>2</sub>O molecules. The pumping source was a CO<sub>2</sub>-laser with transverse excitation supplying pulses of  $3 \cdot 10^{-7}$  s duration and 1 J energy. The submillimeter laser was 1 m long and 80 mm in diameter, with reflectors having a radius of curvature equal to 0.9 m. The energy, the width, and the time delay of submillimeter emission pulses were measured over a wide range of working gas pressures. The pulse width could thus be varied from 0.3 to 2 us, while the pulse energy peaked sharply within an optimum pressure range above which also the time delay ceased to further decrease. The optimum pressures for all four molecules were found to lie within the 0.5-4 mm Hg range. Figures 3; tables 1; references 3 (Russian).

USSR

RELATIVISTIC COMPTON-EFFECT LASER AS A POWER SOURCE

Moscow PIS-MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 28 No 4, 20 Aug 78 pp 207-211 manuscript received 26 Jan 78; after revision 22 Jun 78

BRATMAN, V. L., GINZBURG, N. S. and PETELIN, M. I., Institute of Applied Physics, USSR Academy of Sciences

[Abstract] Stimulated emission of coherent radiation with the aid of stimulated Compton scattering of an electromagnetic wave by relativistic electrons has already been considered. Here the problem of optimizing the parameters of such a laser is treated on the basis of a simple nonlinear theory, according to which the average motion of an electron can be described by the same equations as those applicable to a traveling-wave tube. The conditions of maximum efficiency are established on this basis, namely the optimum frequency deviation from exact synchronism and the optimum electric field intensities, signal and pumping, in fact attainable only in system with a sufficiently long interaction space. Also the starting current is calculated. A relativistic Compton-effect laser delivering an emission power of the

order of  $10^8$  W with frequency tuning over the 2000-100  $\text{\AA}$  range of wavelengths is already practical, with pumping from a CO<sub>2</sub>-laser at a rate of  $10^{10}$ - $10^{11}$  W at the  $\lambda = 10.6 \mu\text{m}$  wavelength. The authors thank A. V. Gaponov, A. G. Litvak, A. V. Smorgonskiy, and Ye. V. Suvorov for the useful comments. Figures 2; references 5: 3 Russian, 2 Western.

USSR

EXPERIMENTAL DETERMINATION OF THE FRACTION OF ENTRAINED PARTICLES AND OF THE EXCITATION LEVEL DURING MANY-PHOTON EXCITATION OF MOLECULES BY INFRARED LASER RADIATION

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 28 No 4, 20 Aug 78 pp 246-251 manuscript received 7 Jul 78

AMBARTSUMYAN, R. V., MAKAROV, G. N. and PURETSKIY, A. A., Institute of Spectroscopy, USSR Academy of Sciences

[Abstract] The fraction of excited particles and their excitation level are two basic parameters of many-photon excitation, both depending on the frequency and the energy density of the laser radiation. Here simple experimental methods of measuring them directly on the basis of this dependence are proposed. In the first method  $q, l$  are determined from the saturation curve of dissociation with a nonresonant field, which follows excitation with a resonant field. In the second method they are determined from their frequency characteristics. Measurement of the many-photon absorption of both the exciting radiation and the dissociating radiation, while the dissociation yield is saturated, yields not only the fraction of excited molecules and their excitation level but also the dissociation energy. These methods were successfully tested on OsO<sub>4</sub> molecules irradiated from a CO<sub>2</sub>-laser at an infrared wavelength. Figures 3; references 5: 2 Russian, 3 Western.

USSR

EFFECT OF A PLASMA ON THE INTERACTION BETWEEN LASER RADIATION AND A METAL

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 75 No 2(8), Aug 78 pp 494-503 manuscript received 11 Jan 78

ZHIRYAKOV, B. M., POPOV, N. I. and SAMOKHIN, A. A., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] An experimental study was made, supported by a theoretical analysis, to determine the behavior of a plasma jet as well as the trend of the recoil force and pressure at the surface of a lead target irradiated in air with quasi-steady millisecond pulses from a neodymium laser at the  $\lambda = 1.06 \mu\text{m}$  wavelength. Measurements were made with an oscilloscope and a piezoelectric transducer. The results are interpreted on the basis of a thermal model with surface evaporation as the principal mechanism of liquid-to-gas phase transformation. Pressure fluctuations at an incident laser radiation intensity of about  $2 \text{ MW/cm}^2$  and separation of the plasma jet from the target surface were found to occur not only after a gradual decrease of the optical thickness of the jet but also as a result of appreciable absorption of radiation. Figures 4; references 17: 14 Russian, 3 Western.

USSR

UDC 621.378.325

LOCAL PROBING OF THE PLASMA OF AN ARGON LASER

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 8, Aug 78 pp 1663-1671 manuscript received 5 Dec 77

KITAYEVA, V. F., OSIPOV, YU. I., PIKALOV, V. V., PREOBRAZHENSKIY, N. G., SOBOLEV, N. N. and FRUMIN, L. L., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] Local plasma probing by the Langmuir method becomes difficult in the case of an Ar<sup>+</sup>-laser with high discharge currents. For this reason, a pulse method of measuring the probe characteristics has been developed. It is possible by this method to determine the energy distribution of electrons and to correct for its departure from a Maxwellian one. The apparatus includes a quartz discharge tube (diameter 1 cm, length 40 cm) and a tungsten probe (diameter 0.1 mm, length 1 mm) injected into the latter for approximately 35 ms by a pulse electromagnet. The probe characteristic at individual points inside the plasma is recorded within 0.2-0.5 ms, with the probe located accurately within 0.1 mm. The results of these measurements are

subsequently interpreted in terms of a mathematical model describing the energy distribution of electrons at the convex probe surface, and by appropriate curve fitting. Typical distributions at several points on the diameter are shown, compared to a Maxwell distribution and also to Dryuvestein distribution. In the description of non-Maxwellian distributions it is appropriate to consider the complete kinetic Boltzmann equation below and above resonance. Figures 5; references 19: 11 Russian, 2 German, 6 Western.

USSR

UDC 621.378.325

TRANSIENT PROCESSES IN A TWO-MODE GAS LASER

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 8, Aug 78 pp  
1700-1705 manuscript received 20 Jun 77

KOZIN, G. I. and PROTSENKO, YE. D., Moscow Institute of Engineering Physics

[Abstract] A high-sensitivity wideband optical discriminator has been developed on the principle of a two-mode gas laser, where two stable longitudinal modes are emitted with their separation exceeding some critical frequency interval. Here the time resolution of such a discriminator is analyzed on the basis of the equations of laser dynamics. In this case the laser parameters vary with time in such a manner that the total emission level remains constant. Mode switching is considered, which involves solving the transient equations for such a laser. Experimental data obtained with a He-Ne laser operating at the  $3s_2 \rightarrow 3p_4$  transition, with proper mode splitting and extraction, are evaluated accordingly. The transient time is found to increase linearly with increasing gain-over-loss excess. The transient time is also found to become longer with decreasing mode separation, but after reaching the maximum length it continues to become shorter--owing to an appreciable asymmetry with respect to the amplification curve. Figures 6; references 7: 5 Russian, 2 Western.

USSR

UDC 621.378.325

A MONOPULSE LASER ON NEODYMIUM GLASS WITH POLARIZED RADIATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1429-1434  
manuscript received 7 Jul 77

VITRISHCHAK, I. B., SIDORENKO, YU. K., and SOMS, L. N.

[Abstract] A monopulse laser on a solid-state active element such as neodymium glass operating in the periodic mode can be produced by a sufficiently fast transition from the high-loss instability region to the low-loss stability region, i.e., Q-switching. This possibility is analyzed here, first theoretically, with the resonator in the form of a thin plate of unequal stabilities with respect to x- and y-polarization. This eliminates the need for a polarizer and thus reduces the losses. It is analyzed further on the basis of experimental data. A prototype of such a monopulse laser had been built, with a Pockels cell as the shutter and with the active element 10x3x120 mm<sup>3</sup> in size made of grade GLS2 glass, and an IFP-1200-2 lamp inside a diffusive reflector used for pumping. Pumping with pulses of 375 J energy at a repetition rate of 4 Hz yielded emission pulses of 35 mJ and 0.3-50 ns duration. Figures 4; references 6: 4 Russian, 2 Western.

USSR

UDC 621.378.325

A PERIODIC YAG:Nd<sup>3+</sup> LASER WITH ELECTRO-OPTICA Q-SWITCHING

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1435-1443  
manuscript received 7 Jul 77

KAMACH, YU. E., KOZLOVSKIY, YE. N., OVCHINNIKOV, V. M., SIDORENKO, YU. K., and SOMS, L. N.

[Abstract] The feasibility of combining in a single electro-optic device all advantages of shutters with two optical paths was studied, both theoretically and experimentally, in a periodic laser with a YAG:Nd<sup>3+</sup> active element. A class 42m DKDP single crystal served as the shutter, in the form of a straight prism, its dimensions designed for optimum performance with an active element having a strong intrinsic or induced birefringence and with a totally reflecting glass prism. Such a shutter was found to be a rather efficient Q-switch, adding 18% losses to the resonator at a pumping threshold of 9 J. The self-excitation threshold of such a laser was found to be about 60 J. Figures 3; tables 1; references 15: 9 Russian, 6 Western.

USSR

UDC 621.375.82

KINETICS OF PHYSICAL PROCESSES IN A CHEMICAL CO-LASER WITH SUPERSONIC PUMPING

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1444-1455  
manuscript received 7 Jul 77

BIRYUKOV, A. S., KULAGIN, YU. A., and SHELEPIN, L. A., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] The feasibility of producing a chemical gas-dynamic laser by mixing  $\text{CS}_2 + \text{CS} + \text{O}_2 + \text{O}$  at supersonic velocities in the nozzle is examined here theoretically. The analysis is based on the appropriate equations of chemical kinetics describing the rates of the chemical reactions and the densities of the atomic components in the mixture, on the probabilities of VT-relaxation and VV- or VV'-exchange processes, and on the temperature-velocity-composition equations of a quasi-one-dimensional flow for a variable-composition mixture. The results indicate that, depending on the initial conditions such as large amounts of atomic oxygen and CS radical within the reaction zone and a low injection temperature (300-500 K), it is possible to achieve a high gain ( $\alpha_{n,n-1} \approx 0.1 \text{ cm}^{-1}$ ) and a high inversion ( $\Delta_{n,n-1} \approx 10^{14} \text{ cm}^{-3}$ ) in vibrationally-rotationally excited CO molecules. Wide nozzle divergence angles and thus high cooling rates yield the maximum gain at the  $n=12 \rightarrow 11$  transition, while small angles cause the maximum gain to decrease and shift toward lower-level transitions. There is also an optimum  $\text{CS}_2$  pressure for maximum gain. Figures 6; tables 1; references 37: 10 Russian, 27 Western.

USSR

UDC 621.378.33

A PHOTOCHEMICAL LASER ON AN XeO MOLECULE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1456-1464  
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DATSKEVICH, I. S., ZUYEV, V. S., MIKHEYEV, L. D., and POGOREL'SKIY, I. V., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] The feasibility of producing a laser with up to  $100 \text{ W/cm}^2$  intensity on the  $\text{XeO}({}^1\text{S}) \rightarrow \text{XeO}({}^1\text{D})$  transition by pumping an  $\text{N}_2\text{O} + \text{Xe}$  mixture has already been established theoretically. The practical feasibility of such a laser was studied in an experiment with electric-discharge pumping of active laser mixtures containing 99.9% pure  $\text{N}_2\text{O}$  (less than 0.1% NO)

and 99.9% pure xenon (0.08% Kr), with or without 99.9% pure argon as the third component. The  $N_2O:Xe:Ar = 1:40:250$  ratio at a total pressure of 1.75 atm was found to be the optimum one, yielding an emission energy of at least 0.6 J or 8 mJ/cm<sup>3</sup> at the green wavelength  $\lambda = 0.54 \mu\text{m}$ , with a gain of  $1.5 \cdot 10^{-3} \text{ cm}^{-1}$  corresponding to a  $XeO(^1S)$  concentration of the order of  $10^{14} \text{ cm}^{-3}$ . Figures 8; references 15: 3 Russian, 12 Western.

USSR

UDC 621.378.9

A SEMICONDUCTOR LASER WITH AN EXTERNAL TUNING REFLECTOR PRODUCED BY CESIUM-133 VAPOR

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1465-1470  
manuscript received 8 Jul 77

VELICHANSKIY, V. L., ZIBROV, A. S., NIKITIN, V. V., SAUTENKOV, V. A., MALYSHEV, V. K., and KHARISOV, G. G., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] It is possible to narrow down the emission spectrum of a wide-band laser by utilizing the dispersion characteristics of atomic lines. In this experiment a cell containing cesium-133 vapor under various pressures from 1.1 to 7 mm Hg was used as an external specular reflector with injection lasers on  $Al_xGa_{1-x}As$  heterostructures. The duration and the repetition rate of pumping current pulses were varied from 10 to 1000  $\mu\text{s}$  and from 20 to  $10^4$  Hz respectively. The width of the emission lines was measured with a spectrograph ( $\delta\lambda = 3 \cdot 10^{-2} \text{ nm}$ ), an interferometer ( $\delta\lambda = 1.2 \cdot 10^{-3} \text{ nm}$ ), or an absorption cell also containing cesium vapor (width of the absorption line 0.8 GHz, taking into account the optical density). The emission spectrum was found to consist of one line within the D<sub>2</sub>-band of cesium-133 (852.1 nm). Emission within the resonance bands of other alkali metal (rubidium D<sub>2</sub>-line at 780 nm or potassium D<sub>1</sub>-line at 769.9 nm) from  $Al_xGa_{1-x}As$  solid solutions of the proper composition can also be obtained with the aid of a reflector produced by the corresponding vapor. The characteristics of such reflectors need to be further studied, with instruments having a sufficiently high resolution, so that the emission power of these sources can be increased. Figures 4; references 15: 5 Russian, 10 Western.

USSR

UDC 621.378

TRANSFORMATION OF A GAUSSIAN BEAM BY COMPONENTS OF A LASER ANEMOMETER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1476-1484  
manuscript received 14 Jul 77

BOGDANOV, S. V., RINKEVICHYUS, B. S. and CHUDOV, V. L., Moscow Power Engineering Institute

[Abstract] The transformations of a Gaussian beam passing through various components of a laser anemometer, namely through the set of lenses and the slanting plane-parallel plates as well as through medium layers with different refractive indexes, are calculated here with the aid of the transmission matrix. A laser anemometer operating in either the differential mode or the reference-wave mode is considered, it being necessary in each case to locate a beam constriction as well as to determine the curvature variation and the beam radius within a constriction as functions of the incidence angle. Also needed are the beam parameters in the photoreceiver plane, where the scattered wave and the reference wave mix. The general relations have been applied to a typical optical system with a high spatial resolution and consisting of two focusing lenses, the bisector of the angle between beams assumed to be normal to the surface. Here intersection of beams in the sagittal plane occurs within constrictions, while their intersection in the meridional plane occurs outside constrictions. The beam intensity distribution over the meridional plane as well as the caustic surface in both planes have also been calculated. Finally, the effect of defocusing on account of this astigmatism during scanning of an object has been evaluated. The authors thank V. A. Fabrikant and Ye. F. Ishchenko for the useful comments and suggestions. Figures 6; references 6 (Russian).

USSR

UDC 539.196:541.182.2/3

KINETICS OF VIBRATIONAL RELAXATION OF MOLECULES IN A GAS-AEROSOL SYSTEM AND LASERS USING TWO-PHASE MEDIA

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1492-1498  
manuscript received 15 Jul 77

KONYUKHOV, V. K. and FAYZULAYEV, V. N., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] When aerosol particles are formed by condensation of a cold gas, they may interact with gaseous molecules and accelerate relaxation processes. This situation is considered here, particularly the mechanisms of such a de-activation of vibrationally excited gaseous molecules either by surface interaction with condensate molecules and exchange processes or by inter-molecular damping. A two-phase system consisting of monomers and complexes is considered in general, with interaction between complexes assumed to be negligible. Following an analysis of the relaxation kinetics and the various exchange modes, on the basis of a Boltzmann distribution of both gaseous and liquid molecules with respect to vibrational energy levels, the effect of aerosol particles as a catalyst is then estimated. The feasibility of using such a two-phase system for a laser is illustrated on a cold gas-dynamic  $\text{CO}_2:\text{D}_2$  mixture, the  $\text{D}_2$  molecules carrying the vibrational energy and small amounts of solid  $\text{CO}_2$  aerosol amplifying the nonresonance pumping of gaseous  $\text{CO}_2$  molecules at 100 K by as much as one order of magnitude. The performance parameters of a typical  $\text{CO}_2$ -laser of this kind are calculated. References 10: 6 Russian, 4 Western.

USSR

UDC 621.378.325

NOVEL SCHEMES OF DYE LASERS WITH DISTRIBUTED DYNAMIC FEEDBACK

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1507-1512  
manuscript received 15 Jul 77

VASHCHUK, V. I., ZABELLO, YE. I., and TIKHONOV, YE. A., Institute of Physics, Academy of Sciences of the Ukrainian SSR, Kiev

[Abstract] The feasibility of recording a diffraction grating in a dye solution for the purpose of real-time holography, has already been established. Here dye lasers with distributed dynamic feedback are considered. According to theoretical analysis and experimental evidence, the thermal mechanism contributes more than any other one to the modulation, by optical radiation, of the dielectric permittivity of strongly absorbing media. The characteristics of such a thermal Fresnel diffraction grating are examined and two

optical schemes are shown which make the amplitude-phase diffraction grating independent of the mutual coherence of the pumping sources. The emission frequency can thus be tuned over the entire amplification range of a given dye below the threshold of background superfluorescence. Figures 4; references 12: 2 Russian, 10 Western.

USSR

UDC 621.378.002.2

LONG-TERM INSTABILITY AND NONREPEATABILITY OF THE FREQUENCY OF A GAS LASER  
AND REQUIREMENTS TO BE MET BY AUTOMATIC TUNING SYSTEMS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1518-1524  
manuscript received 15 Jul 77

VLASOV, A. N.

[Abstract] Long-term frequency instability is defined here so that short-term frequency instability in a system with automatic frequency control becomes a negligible factor. An analysis of a gas laser with automatic frequency control reveals that the long-term frequency instability and nonrepeatability depend here on errors in the AFC system components such as the electronic integrator, the synchronous detector, and the amplifier, these errors also including the reference-voltage instability. The results of this analysis indicate how such an AFC system must be corrected for satisfactory performance. References 8: 6 Russian, 2 Western.

USSR

UDC 621.378.33

A HIGH-POWER CO<sub>2</sub> PULSE LASER WITH THE EMISSION FREQUENCY SMOOTHLY TUNABLE  
OVER A WIDE RANGE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1525-1529  
manuscript received 16 Jul 77

BYCHKOV, YU. I., MESYATS, G. A., ORLOVSKIY, V. M., OSIPOV, V. V., and  
SAVIN, V. V., Institute of Atmospheric Optics, Siberian Division of the  
USSR Academy of Sciences, Tomsk

[Abstract] Many applications require a source of coherent infrared radiation with a smoothly tunable frequency. A CO<sub>2</sub>-laser has been considered for this purpose, but increasing the energy of an emission pulse beyond

0.2 J with a minimum change in radiation intensity during transition from one vibrational-rotational spectral line to another requires high pressures in large volumes of an active medium with high levels of energy absorption. The emission energy and spectral characteristics of such a CO<sub>2</sub> pulse laser were studied in an experiment, with the excitation provided by an electron beam of 2 A/cm<sup>2</sup> density and 1.2  $\mu$ s pulse duration coming from a direct-action accelerator triggered by a 350 kV voltage pulse. The diffraction grating as the resonator tuning element was mounted with its axis of rotation normal to the plane of the electrodes, so as to avoid the radiation reflected from the electrodes. The optimum pressure for a CO<sub>2</sub>:N<sub>2</sub> = 1:1 mixture was found to be 4 atm, above which neither the emission energy increased much further nor the gain became more uniform over the frequency range. An emission energy of 5.8 J at the center of the 102 cm<sup>-1</sup> total tuning range could be generated with an efficiency of 2.2%. Figures 6; references 7: 5 Russian, 2 Western.

USSR

UDC 535.5:621.371.24

EFFECT OF THE DIFFRACTION APERTURE DIMENSION AND OF THE TURBULENCE SPECTRUM  
ON THE INTENSITY FLUCTUATIONS OF LASER RADIATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1535-1541  
manuscript received 18 Jul 78

BANAKH, V. A. and MIRONOV, V. L., Institute of Atmospheric Optics, Siberian Division of the USSR Academy of Sciences, Tomsk

[Abstract] The relative dispersion of laser intensity fluctuations and its dependence on the Fresnel diffraction aperture dimension are analyzed on the basis of the Huygens-Kirchhoff theory. With a Gaussian distribution of the complex field amplitude at the exit from the optical transmitter given, the dispersion integral is evaluated asymptotically including the effect of turbulence. Both weak and strong intensity fluctuations are considered, but the latter case is dealt with more thoroughly, also with the Fraunhofer zone of diffraction. According to the results of this analysis, the field coherence radius is the principal parameter which determines the trend of the aperture dependence of that dispersion. Within a confined laser beam, moreover, the dispersion of intensity fluctuations saturates at a level which exceeds unity by an amount determined by the ratio of internal turbulence scale to dimension of the transmitter aperture. The authors thank K. S. Gochelashvili and V. I. Shishov for the helpful discussion of problems arising in this study. References 19: 16 Russian, 3 Western.

USSR

UDC 621.378

STIMULATED UNDULATOR EMISSION OF RELATIVISTIC ELECTRONS AND PHYSICAL PROCESSES IN AN 'ELECTRONIC LASER'

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1543-1552  
manuscript received 19 Jul 77

KOLOMENSKIY, A. A. and LEBEDEV, A. N., Institute of Physics imeni P. N.  
Lebedev, USSR Academy of Sciences, Moscow

[Abstract] Stimulated undulator emission (magnetic bremsstrahlung) of electrons at optical or shorter wavelengths as a source of an "electronic laser" is considered. Such an emission requires a spontaneous emission first and a positive feedback to ensure an exponential buildup of the coherent radiation field at a given frequency. Furthermore, the probability of spontaneous emission at the given frequency must coincide with an energy increase. Accordingly, the spontaneous-emission spectrum and the gain characteristics are calculated from the classical standpoint as well as from the standpoint of "photon gas" kinetics. The maximum attainable saturation power, determined by reaction of the wave on the electron beam, and the electronic efficiency are estimated according to the linear theory and disregarding any technological limitations. Theoretically, the maximum electronic efficiency could be increased above 1% by decreasing the number  $N$  of periods, to which it is inversely proportional. However, the gain would then decrease as  $N^3$ . The authors thank V. S. Voronin for assisting with the numerical calculations. Figures 2; tables 1; references 9: 5 Russian, 4 Western.

USSR

UDC 621.373.826.038.823

CUTTING OF NONMETALLIC MATERIALS WITH A CO<sub>2</sub>-LASER BEAM

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1553-1558  
manuscript received 19 Jul 77

UGLOV, A. A., KOKORA, A. N., and BERLIN, N. V., Institute of Metallurgy imeni A. A. Baykov, USSR Academy of Sciences, Moscow

[Abstract] Experimental data are presented which pertain to automatic cutting of leatheroids with a gas-laser beam. A multimode CO<sub>2</sub>-laser of 500 W power was used with a KCl focusing lens. An analysis of these data reveals how the slit width and the slit depth depend on the laser beam focusing, the minimum width and the maximum depth being attained with the material

less than 5 mm from the focal plane, as well as how the slit width and the cutting speed depend on the laser beam power. Some characteristics of the laser cutting technology can also be deduced from these data and known theoretical relations, namely the width of the heat-affected zone and the slit width as a function of the cutting speed under a given air pressure. Figures 5; tables 1; references 3 (Russian).

USSR

UDC 621.378.33

ABSORPTIVITY OF METALLIC TARGETS IRRADIATED WITH A PULSE-PERIODIC CO<sub>2</sub>-LASER  
IN AIR

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1567-1575  
manuscript received 6 Jul 77

ARZUOV, M. I., KARASEV, M. YE., KONOVA, V. I., KOSTIN, V. V., METEV, S. M.,  
SILENOK, A. S., and CHAPLIEV, Institute of Physics imeni P. N. Lebedev, USSR  
Academy of Sciences

[Abstract] The absorptivity of metals, defined as the fraction of laser energy lost on heating the target, was measured in air. A pulse-periodic CO<sub>2</sub>-laser with an average power of 30 W and a pulse repetition rate of 100 Hz as well as an industrial continuous-wave LG-25 CO<sub>2</sub>-laser with an average power of 35 W were used for irradiating copper, duralumin, and grade St-3 steel targets through a NaCl lens. First the "cold" absorptivity of these metals was measured as a function of the air pressure. The effect of heating and the effect of a plasma due to air breakdown at the target surface were determined, also the effect of oxidizing reaction on the heating curve for a given metal. As a result, it has been possible to establish the temperature dependence of the effective absorptivity for these metals, from room temperature to their respective melting points. The authors thank A. I. Barchuk and F. V. Bunkin for the continuous interest in this study and for the helpful discussions. Figures 8; tables 1; references 7: 5 Russian, 2 Western.

USSR

UDC 621.373.826.038.823

AN ULTRAVIOLET N<sub>2</sub>-LASER OF A HIGH POWER DENSITY AT A HIGH PULSE REPETITION RATE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1580-1582  
manuscript received 2 Nov 77

PAPAKIN, V. F. and SONIN, A. YU., Rostov State University

[Abstract] Overheating of the active medium in a nitrogen laser has been found to be the major cause of reduced emission power with increasing pulse repetition rate. In a typical nitrogen laser emitting at an ultraviolet wavelength with transverse excitation the thermal conductivity of the nitrogen plasma can exceed that of gaseous nitrogen by several orders of magnitude. In an experimental study the relaxing plasma was brought into direct contact with the heat conducting alundum walls of the discharge chamber. This effective cooling of the plasma yielded a maximum average emission power of 210 mW at a pulse repetition rate of 400 Hz with a capacitance of 5 nF in the excitation circuit, or 75 mW at 800 Hz with a capacitance of 2.35 nF in the excitation circuit. Even higher pulse repetition rates, of the order a few kilohertz, and peak power densities above 40 kW/cm<sup>3</sup> on the C<sup>3</sup>II<sub>u</sub>-B<sup>3</sup>II<sub>g</sub> transition seem to be feasible with a further optimized design of the discharge chamber and the excitation circuit. The authors thank V. S. Filip'yev and V. G. Levents for constructing the discharge chamber. Figures 1; references 6: 4 Russian, 2 Western.

USSR

UDC 621.373.826.038.825.3

USE OF A NEODYMIUM GLASS LASER FOR DEPOSITING FILMS OF CHEMICAL ELEMENTS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1582-1584  
manuscript received 11 Nov 77

BOYAKOV, V. M., YEPIKHIN, V. M., KALIN, B. A., MAKHATOV, M. K., NIKOLAYEV, I. N., and SHISHKIN, G. N., Moscow Institute of Engineering Physics

[Abstract] A neodymium glass laser was experimentally used for depositing polycrystalline films of 39 elements in the Periodic Table on substrates of glass, mica, or sodium chloride. This method is characterized by a very high deposition rate, resulting in crystallization under extreme conditions. In order to make the film thickness more uniform without reducing the evaporation rate, the laser was operated in a quasi-continuous mode of 1 pulse/min with a maximum energy of 120 J/pulse simulating the characteristics of free emission. Deposition was effected with the targets under a rather moderate

"static" vacuum ( $\sim 10^{-1}$   $\mu\text{m Hg}$ ) and yet a high "effective vacuum equivalent to  $10^{-4}$   $\mu\text{m Hg}$ , owing to the very fast microsecond duration of the evaporation process. For layer-by-layer deposition of thick films, the surface after each pass had to be decontaminated of adsorbed gases by means of a lower-intensity second laser. Elements with a high optical reflectivity (aluminum, silver, copper) could be evaporated only after their surface had been blackened with graphite. The authors thank Yu. A. Bykovskiy for the interest in this experiment. Figures 2; references 9: 4 Russian, 5 Western.

USSR

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#### AN ULTRAVIOLET GOLD VAPOR LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1585-1587  
manuscript received 26 Nov 77

MARKOVA, S. V., PETRASH, G. G., and CHEREZOV, V. M., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] An experimental study was made of a gold laser at the 312.2 nm wavelength, with helium, neon, argon, xenon, or nitrogen as buffer gas sustaining the discharge inside a cold ceramic tube. The pulse width was measured as a function of the emission power and as a function of the gas pressure. The emission power was measured, moreover, as a function of time, i.e., heating. Under a pressure of 8.2 mm Hg in neon, for instance, the intensity of ultraviolet emission peaked after 9 min and then dropped sharply, while the intensity of red emission at the 627.8 nm wavelength continued to rise. Under much higher pressures, on the other hand, red emission preceded ultraviolet emission. With optimum tube dimensions and discharge parameters, emission pulses of an average power of 1.2 kW and at a repetition rate of 9.1 kHz were generated by gold vapor at its ultraviolet wavelength. Superluminosity of both spectral lines was noted. The authors thank A. A. Isayev and G. Yu. Lemmerman for supplying the apparatus with a powerful discharge excitation source. Figures 3; references 6: 5 Russian, 1 Western.

USSR

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FEASIBILITY OF MECHANICAL SELF-PUMPING OF THE GAS MIXTURE IN A PERIODIC PULSE LASER

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manuscript received 29 Dec 77

GUBAREV, A. V., DROBYAZKO, S. V., and YAKUSHEV, A. A.

[Abstract] A major problem in operating a continuous-flow gas-discharge laser with a  $N_2+CO_2+He$  mixture is ensuring a closed cycle. It is thus necessary to devise means for pumping the mixture through a closed system with minimum leakage and energy loss. This problem is considered here as one of self-pumping, without the limitations due to shock waves. It is analyzed in terms of gas dynamics, namely pressure-time curves and pressure profiles at various temperatures. It is also analyzed in thermodynamic terms, the cycle in the discharge chamber consisting of four processes: 1) gas intake under constant pressure, 2) heat delivery to a constant volume, 3) adiabatic expansion, 4) gas exhaust. In the system described here the first and the last of these processes occur simultaneously. At a typical compression ratio of 2.5 sufficient heat in the discharge gap is converted to mechanical work to overcome hydraulic drag throughout the system. Utilization of this heat for pumping the gas through the system thus increases the overall efficiency of such a laser. Figures 4; references 6: 3 Russian, 3 Western.

USSR

UDC 621.378:621.039.2

THIRD ALL-UNION SCIENTIFIC-TECHNICAL SEMINAR ON SEPARATION OF ISOTOPES WITH A LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1614-1617

KORNILOVA, A. I.

[Abstract] The third scientific-technical seminar on separation of isotopes with a laser was held in Bakuriani (Georgian SSR) 5-12 March 1978, organized jointly by the Institute of Spectroscopy (USSR Academy of Sciences in Troitsk, Moscow Oblast'), the Scientific Research Institute of Stable Isotopes (Tbilisi), and the Sukhumi Physico-Technical Institute. The USSR Academy of Sciences was also represented by delegates from its Institute of Physics, Institute of Chemical Physics, Institute of Atomic Energy, as well as the Institute of Chemical Kinetics and Combustion and the Institute of Thermophysics at its Siberian Division. Among other institutions represented was the Moscow

State University. The four topics covered in this seminar were: 1) selective many-photon excitation and dissociation of molecules by infrared radiation, 2) laser techniques of separating isotopes, 3) atomic viewpoint on separation of isotopes by a laser, and 4) laser spectroscopy of molecules. Latest studies and progress were reported concerning the application of chemical lasers on gaseous CO, CO<sub>2</sub>, NH<sub>3</sub>, CF<sub>4</sub>, N<sub>2</sub>, XeCl, and XeF molecules. The

ultimate goal of these seminars is fourfold: 1) gaining basic knowledge about elementary processes in atoms and molecules due to laser action, 2) developing a design of an optimum laser cell for isotope separation, 3) producing lasers for optimization of the isotope separation process, and 4) building an experimental prototype of an industrial isotope separating laser apparatus.

Magnetohydrodynamics

USSR

UDC 621.378.9:533.9.02

EXPERIMENTAL INVESTIGATION OF CUMULATIVE EFFECTS IN A PLASMA FOCUS AND IN A LASER PLASMA

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA.  
MOSHCHNYYE LAZERY I LAZERNAYA PLAZMA [Transactions of the "Order of Lenin"  
Physics Institute imeni P. N. Lebedev. High-Power Lasers and Laser Plasmas]  
in Russian Vol 85, 1976 pp 193-237

GRIBKOV, V. A., KROKHIN, O. N., SKLIZKOV, G. V., FILIPPOV, N. V.\* and  
FILIPPOV, T. I.\* [\*Institute of Atomic Energy imeni I. V. Kurchatov]

[Abstract] It is shown by the method of high-speed laser interferometry on two wavelengths, high-speed multiple-frame schlieren photography, investigation of x-radiation and neutron radiation and also by a probe technique that processes of cumulation in a plasma focus and in a laser plasma of special geometry take place in two stages--hydrodynamic and kinetic.. In the first stage, both in MHD cumulation (plasma focus) and in the case of hydrodynamic cumulation (laser plasma), the principal processes are determined by formation of a cumulative jet. In the second stage, a powerful relativistic electron beam is formed in the plasma focus that interacts strongly with the plasma, while in the cumulative laser plasma powerful Langmuir noise is generated that leads to formation of a group of fast electrons (up to 1% of the total quantity) with energy 5-10 times greater than that of the main mass of electrons. The authors thank Academician N. G. Basov for interest and support of the work, Yu. V. Afanas'yev, V. S. Imshennik and V. V. Pustovalov for valuable consultations, and V. Ya. Nikulin and V. N. Korzhavin for assisting with the experiment. Figures 25; references 93: 48 Russian, 1 Rumanian, 44 Western.

USSR

UDC 537.633.9

INFLUENCE OF A MAGNETIC FIELD ON A VOLUMETRIC DISCHARGE EXCITED BY AN ELECTRON BEAM

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1155-1157  
manuscript received 10 Sep 77

ARONIN, YU. V., DOLGOV-SAVEL'YEV, G. G., KOZOROVITSKIY, L. L., ORISHICH, A. M., ORLOV, V. K. and PONOMARENKO, A. G., Institute of Theoretical and Applied Mechanics, Academy of Sciences USSR, Novosibirsk

[Abstract] The authors consider the use of an electron beam in excitation of a semi-self-maintained volumetric discharge, and show that the magnetic field due to the main discharge may have a detrimental influence on the beam excitation process. Experiments were done in which an electron beam from an accelerator was injected through an aluminum foil into the discharge gap formed by a high-voltage electrode and a special metal grid with 60% transparency. The parameter  $E_0/p$  was held constant throughout the discharge. Permanent magnets were used to determine the influence that a transverse magnetic field has on the uniformity of ionization and the electric energy absorbed in the discharge. The field was varied by changing the number of magnetic plates. The experiments showed that the transverse magnetic field has a considerable effect on uniformity of a semi-self-maintained volumetric discharge and limits the absorbed electric energy when the distance between electrodes is equal to twice the Larmor radius of electrons. This result shows that the magnetic field of the discharge current must be considered as a limiting factor in designing electron beam-controlled lasers. Figures 2; references 6: 5 Russian, 1 Western.

USSR

NONLINEAR THEORY OF EXCITATION OF MONOCHROMATIC WAVES IN A MAGNETICALLY ACTIVE PLASMA BY A RELATIVISTIC BEAM OF CHARGED PARTICLES

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 75 No 2(8), Aug 78 pp 484-493 manuscript received 4 Oct 77

KITSENKO, A. B. and PANKRATOV, I. M., Physicotechnical Institute, Academy of Sciences of the Ukrainian SSR

[Abstract] Excitation of monochromatic waves in a magnetically active plasma by a relativistic monoenergetic low-density electron beam is considered, with the fundamental equations of this interaction being based on a given initial momentum distribution of electrons in the beam and a "cold" homogeneous plasma with some given polarization in an external magnetic field. The

linear theory is applicable to the initial linear range of oscillation buildup, but a nonlinear theory is constructed here for the range of beam instability. With the exponential buildup of the wave amplitude attributable to entrapment of beam particles by the field of this amplified wave, the conditions for sustaining synchronism are found to improve as the component of its phase velocity parallel to the external magnetic field approaches the velocity of light. In the case of Cherenkov resonance this is possible with ultrarelativistic beams. In the case of cyclotron resonances this is possible with the wave frequency near a harmonic of the gyration frequency of beam particles. The authors thank K. N. Stepanov for the discussion of the results. References 17: 15 Russian, 2 Western.

USSR

MECHANISM OF EROSION OF METALLIC ELECTRODES IN AN MHD-GENERATOR CHANNEL

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 16 No 4, Jul/Aug 78  
manuscript received 11 Jan 78

BEYLIS, I. I., Institute of High Temperatures, USSR Academy of Sciences

[Abstract] The erosion of copper cathodes in an MHD channel is analyzed on the basis of theoretical considerations and experimental data, the latter obtained by high-speed photography and current measurements at 600-1200 K, pertaining to operation with a constricted discharge. The behavior of two kinds of arc spots, fast shifting ones and almost stationary ones, indicates that erosion of the cathode material depends on the work function of this material as well as on the spot current, i.e., the electric field intensity at the cathode. With the true values of these parameters under given conditions known, it is possible not only to explain the high erosion rate qualitatively but also to estimate it quantitatively. Spots of the second almost stationary kind appear to play the dominant role here, namely by affecting the evaporation of the cathode material. Figures 1; tables 2; references 10: 6 Russian, 4 Western.

USSR

UDC 621.313.12:538.4

COMPARISON OF FLOW CALCULATIONS FOR AN MHD-GENERATOR CHANNEL WITH EXPERIMENTAL DATA OBTAINED ON THE U-25 TEST FACILITY

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 16 No 4, Jul/Aug 78  
pp 854-867 manuscript received 28 Dec 77

BITYURIN, V. A., ZHELNIN, V. A., LYUBIMOV, G. A., and MEDIN, S. A., Institute of High Temperatures, USSR Academy of Sciences, Scientific Research Institute of Mechanics, Moscow State University

[Abstract] The flow in an MHD-generator channel is calculated here on the basis of a homogeneous hydrodynamic model, with the generalized Ohm's law referred to cross-sectional average quantities. The results are compared with those of measurements on the U-25 test facility and appropriate correction factors are established accordingly. All empirical quantities involved in this analysis fall into three groups, in terms of their physical significance, namely: those which depend on the mode of flow, those which account for the channel characteristics, and those which also depend on the mode of flow but only to the extent that their variation does not affect the accuracy of the results. Most uncertain is the correction factor for the electrical conductivity, while the correction factors for the friction coefficient and the heat transfer coefficient are quite conservative with respect to changes in the flow conditions. Figures 8; tables 2; references 10 (Russian).

USSR

UDC 537.561

ELECTRICAL PROPERTIES OF A PLASMA JET CARRYING SOLID PARTICLES

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 16 No 4, Jul/Aug 78  
pp 709-712 manuscript received 2 Feb 78

GORBATOV, A. V. and SAMUYLOV, YE. V., Institute of Power Engineering imeni G. M. Krzhizhanovskiy, Moscow

[Abstract] The electrical properties of a hot supersonic underexpanded plasmasol are calculated, assuming that the concentration and the temperature of both solid particles and gas molecules are known from gas-dynamic considerations. On this basis, and for the particularly interesting case of the mean free path of electrons during collisions with gas molecules larger than the radius of solid particles, expressions are derived in the quasi-steady approximation for the electrical conductivity and the electron concentration. Some typical numerical values are given. References 6: 3 Russian, 3 Western.

USSR

UDC 538.561

THEORY OF COHERENT UNDULATORY RADIATION: PART 1

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 8, Aug 78 pp  
1592-1597 manuscript received 19 Oct 77

ALFEROV, D. F., BASHMAKOV, YU. A. and BESSONOV, YE. G., Institute of Physics  
imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] Radiation of electromagnetic microwaves from an electron beam in an undulator is analyzed on the basis of the superposition principle. The two conditions of coherence, firstly the smallness of phase differences and secondly the closeness of field vectors in magnitude as well as direction, are expressed in a form which defines the constraints on a source of such radiation. The concept of a coherence factor, differential or integral, is introduced as a means of calculating the efficiency of an undulator, i.e., the ratio of radiation energy to total kinetic energy of the electron beam in it. References 25: 18 Russian, 7 Western.

USSR

UDC 533.95

FORMATION OF RADIAL ELECTRIC FIELDS IN A ROTATING PLASMA

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 8, Aug 78 pp  
1657-1662 manuscript received 1 Nov 77

BEKHTENEV, A. A. and VOLOSOV, V. I., Institute of Nuclear Physics, Siberian  
Division of the USSR Academy of Sciences, Novosibirsk

[Abstract] The feasibility of producing a stable and balanced hot plasma in an open magnetic trap between two coaxial electrodes is studied, such a plasma being rotated by the radial electric field crossing the magnetic field. Additional ring electrodes serve to spread the potential over the plasma. With heating of the plasma assumed to be due to ionization only, and with a correction for its interaction with neutral gas, in a plasma with nearly Maxwellian velocity distributions of ions and electrons the potential distribution is shown to be determined principally by axial currents. In the second extreme case of negligible axial currents the radial profile of the electric field is shown to be determined by the transverse conduction. While in the first case a high degree of ionization is required for producing a stable and balanced hot plasma with a sufficiently high ion energy, in the second cases a positive radial concentration gradient throughout the plasma volume is needed for stabilization and this can be achieved by using electron sources at the end electrodes. The authors thank F. A. Tsel'nik for the stimulating comments. Figures 2; references 12: 8 Russian, 4 Western.

Molecular Physics

USSR

UDC 533.95

MEASURING THE EFFECTIVE STICKING PROBABILITY OF FREE ELECTRONS IN THE IONIZED AIR OF A HYPERSONIC WAKE ON A BALLISTIC PATH

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 5, May 78 pp 964-966 manuscript received 11 May 77

BRODSKIY, V. B., ZAGIK, S. YE., LYUTOVSKIY, V. A. and MISHIN, G. I.

[Abstract] A technique is described for determining the effective sticking probability of free electrons in the ionized air in a hypersonic wake behind a copper-clad aluminum sphere 0.4 cm in diameter on a ballistic path. The method is based on measuring the distribution of electron concentration by a cavity method. It was found that the rate of sticking per unit of pressure of the undisturbed air is practically independent of pressure. An effective sticking probability of  $9 \cdot 10^{-15} \text{ cm}^3/\text{s}$  is found. This coefficient characterizes the rate of fall-off in the concentration of electrons in the far section of the wake due to the combined action of all reactions of capture and detachment of electrons. The authors thank I. V. Basargin, V. N. Gadion, V. G. Ivanov, S. N. Palkin and A. M. Khatutskiy for assistance with the experiments. Figures 1; references 2 (Russian).

USSR

UDC 533.922.

MEASURING THE TEMPERATURE DEPENDENCE OF THE COEFFICIENT OF RECOMBINATION OF ELECTRONS IN IONIZED AIR ON A BALLISTIC PATH

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 5, May 78 pp 961-963 manuscript received 22 Apr 77

BRODSKIY, V. B., ZAGIK, S. YE., LYUTOMSKIY, V. A. and MISHIN, G. I.

[Abstract] A technique is described for determining the temperature dependence of the coefficient of recombination of electrons from the measured distributions of electron concentration and temperature along a hypersonic wake. The paper gives the results of measurements in the wake behind a copper-clad aluminum sphere 0.4 cm in diameter at a Mach number  $M_\infty = 12$  and pressure of the undisturbed air on the flight path of 40 mm Hg. It is found that the recombination coefficient is proportional to the negative four-thirds power of temperature with proportionality factor  $2.3 \cdot 10^{-3}$ , which corresponds to the reaction  $\text{NO}^+ + \text{e} = \text{N} + \text{O}$ . It is suggested that the method of measuring the electron recombination coefficient on a ballistic path can be used not only in ionized air, but in other gases and vapors as

well. The authors thank I. V. Basargin, V. N. Gadion, V. G. Ivanov, S. N. Palkin and A. M. Khatutskiy for assisting with the experiments. Figures 2; references 3 (Russian).

USSR

TRANSMISSION OF INFRARED RADIATION WITHIN THE MOLECULAR BANDS OF CARBON DIOXIDE AND WATER VAPOR

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 241 No 1, 1978 pp 84-87  
manuscript received 23 Nov 77

SMIRNOV, B. M. and SHLYAPNIKOV, G. V., Institute of Atomic Energy imeni I. V. Kurchatov, Moscow

[Abstract] To estimate the effect of CO<sub>2</sub> accumulation in the atmosphere on the climate on Earth, first the radiation characteristics of a mixture of molecular gases are determined in the general case. Two components of the mixture are assumed to have overlapping bands, the band of one being a regular one with a smoothly frequency-dependent intensity of spectral lines and the band of the other one being a random one with a jumpwise frequency-dependent intensity of spectral lines. On the basis of this random model, the transmission function is calculated over a frequency range covering many lines of the regular band but sufficiently narrow for assuming their intensities to be all equal. The general relations are then applied to carbon dioxide in the atmosphere with water vapor, and to radiation in the 15 μm wavelength band as well as in the 900-1100 cm<sup>-1</sup> frequency band. Furthermore, on the basis of estimates as to the amounts of carbon dumped into the atmosphere in the form of carbon dioxide by combustion of fuels, temperature changes on Earth are forecast for the next half century. With most of the carbon in combustion products assumed to reenter the biosphere on ground, the CO<sub>2</sub> concentration in air should be 362·10<sup>-6</sup> in the year 2000 and 450·10<sup>-6</sup> in the year 2025 (it was 326·10<sup>-6</sup> in 1977) for corresponding temperature rises of 0.1 and 0.5°C respectively. The paper was presented on 26 Dec 77 by Academician I. K. Kikoin. Tables 1; references 15: 10 Russian, 5 Western.

Nuclear Physics

USSR

UDC 621.378.9:533.9.02

EXPERIMENTAL INVESTIGATION OF REFLECTION AND ABSORPTION OF POWERFUL OPTICAL RADIATION IN A LASER PLASMA

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA. MOSHCHNYYE LAZERY I LAZERNAYA PLAZMA [Transactions of the "Order of Lenin" Physics Institute imeni P. N. Lebedev. High-Power Lasers and Laser Plasma] in Russian Vol 85, 1976 pp 143-192

KROKHIN, O. N., SKLIZKOV, G. V. and SHIKANOV, A. S.

[Abstract] The purpose of this research is to clarify one of the main problems of laser-driven fusion--processes of absorption and reflection of high-power laser radiation in a plasma corona. The authors give the results of experimental studies of processes of interaction of powerful neodymium laser radiation with massive and thin targets in the flux density range of  $10^{10}$ - $10^{15}$  W/cm<sup>2</sup>. A number of effects are detected that show anomalous interaction between radiation and plasma, including plasma generation of harmonics of the incident frequency  $\omega_0$  of the type  $m\omega_0/2$ , where  $m$  is an integer, oscillatory reflection of radiation, and anisotropy of continuous x-radiation relative to the electric field vector of the light wave. Experimental data are compared with predictions of the theory of parametric effects in plasma. Experimental procedures and results are described on the study of emission absorption in thin targets. The authors thank Academician N. G. Basov for continued interest in the work, V. P. Silin for constructive comments, Yu. A. Afanas'yev, V. A. Gribkov, V. V. Pustovalov and S. I. Fedotov for useful discussions, and Yu. A. Zakharenkov, Yu. A. Mikhaylov and A. A. Rupasov for assistance with the experiments and useful discussions. Figures 34; references 162: 80 Russian, 82 Western.

USSR

UDC 621.384.8

HIGH-LUMINOSITY ION SOURCES FOR MASS SPECTROMETERS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 6, Jun 78 pp 1275-1281 manuscript received 30 Jun 77

SYSOYEV, A. A., KALININ, YU. T., ISLAMOV, I. M., KHAFIZOV, R. S., IVANOV, V. P. and TANANYKIN, N. I., Moscow Engineering Physics Institute

[Abstract] A survey of new designs for high-luminosity ion sources with focusing optics, and a report on results of studies of these sources. The principles of physical and mathematical modeling of ion sources are presented. The sources with the highest utilization of material use an annular cathode and an ionization chamber in the form of a frustum of a cone. In

this design, a change in potential of the vaporizer over a range of  $\pm 100\%$  relative to the accelerating potential changes the ion current by no more than 25%, the maximum current being observed with zero potential difference between the vaporizer and the ionization chamber. The ion yield from the ionization space can be increased by modifying the potential distribution on the electrodes of the ion gun. With optimized potential distribution, about 60% of the ions are focused in a spot with 1 mm diameter. In this case, 50% of the ions fall into a solid angle of  $6^\circ$ , and 95% are included in a solid angle of  $20^\circ$ . The large divergence is due to the low ion energy of about 50 eV. Work experience with the ion sources described in the survey has shown that they have excellent analytical capabilities. They have higher luminosity than conventional sources with collimating and focusing optics. The coefficient of ion collection may reach 60%. The sensitivity of a quadrupole mass spectrometer with a source of this type reaches  $2.4 \cdot 10^{-3}$  A/mm Hg, while that of a static mass spectrometer with ion path length of 170 cm reaches  $4 \cdot 10^{-5}$  A/mm Hg. The proposed sources are simple to make, assemble and adjust. Figures 6; references 10 (Russian).

USSR

UDC 537.533.3

CALCULATION OF OPTICAL-SPECTRAL CHARACTERISTICS OF PRISM TYPE ELECTRON SPECTROMETERS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 6, Jun 78 pp 1266-1270 manuscript received 18 Apr 77

SUKHORUKOV, B. L., LABAZIN, A. V. and NIKIFOROV, I. YA., Rostov State University

[Abstract] An examination is made of the problem of improving the optical-spectral characteristics of an electron spectrometer with electrostatic prism analyzer and quadrupole lenses at the input and output. Aberration coefficients were calculated for the entire system up to and including the fourth order, and the shape of the spectral windows was determined for two instruments with optical source in the form of a rectangular slit. In addition, spectrometer resolution was calculated as a function of the "arm"—the distance from the input slit to the collimating lens. It was found that about 40% of all electrons enter the output slit of the spectrometer with height of 4 mm. Distortions of electron spectra introduced by the spectrometer itself can be judged only from the shape of the spectral window of the instrument. The aberration coefficients alone are not sufficient for this purpose. It is advisable to limit the angular divergence of the electron beam to  $3-4^\circ$  (semivertex angle). The optimum arm of the spectrometer

should be at least 10, and not more than 20 cm. The authors thank S. Ya. Yavor, I. A. Petrov and Ye. A. Shpak for constructive criticism and discussion. Figures 6; references 8 (Russian).

USSR

UDC 537.533.3

A TWO-STAGE CYLINDRICAL ENERGY ANALYZER WITH THIRD-ORDER ANGULAR FOCUSING

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 6, Jun 78 pp 1262-1265 manuscript received 14 Jun 77

ZASHKVARA, V. V., IL'IN, A. M. and ASHIMBAYEVA, B. U., Institute of Nuclear Physics, Academy of Sciences Kazakh SSR, Alma-Ata

[Abstract] A technique is proposed for correcting cubic angular aberration and appreciably reducing fourth-order aberration in a two-stage electrostatic energy analyzer of the cylindrical mirror type with an additional axisymmetric electrostatic trajectory-inverting electron mirror located at an intermediate focus. The charged particle beam from the source with given angular divergence enters the first stage of the analyzer, after which it is reflected by the correcting electron mirror, passes through the second stage and is focused on the input aperture of the receiver. The intermediate focus is an annulus that is simultaneously an image of the source in the first stage and an ion-optical source in the second stage. A procedure is outlined for figuring the surface of the correcting mirror. One of the electrodes of the mirror is made of a fine-mesh metal grid with high transparency at ground potential like the inner cylinder of the analyzer, and the other electrode is made of solid metal held at a potential with the same sign as that of the particles to be analyzed and with a magnitude sufficient for reflecting the particles in the interelectrode space. Successful practical realization of the proposed correcting mirror depends on the extent to which the distorting influence of the scattered field at the surface of the grid electrode can be minimized as compared with the positive effect of correction of aberrations. Figures 2; references 6 (Russian).

USSR

UDC 533.9.07

A MULTICHANNEL ENERGY ANALYZER OF NEUTRAL CHARGE-EXCHANGE PARTICLES WITH HIGH TIME RESOLUTION

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 6, Jun 78 pp 1174-1177 manuscript received 26 Apr 76, after final revision 29 Nov 77

BORZENKO, V. P., KOSHILEV, N. A., PARFENOV, O. G. and STROKIN, N. A., Siberian Institute of Terrestrial Magnetism, the Ionosphere and Radio Wave Propagation, Siberian Department of the Academy of Sciences USSR, Irkutsk

[Abstract] The paper describes an eight-channel energy analyzer of neutral charge-exchange particles. The device consists of a gas stripper chamber and an electrostatic ion energy analyzer based on a flat capacitor with entrance angle of  $\theta=45^\circ$  for the particles to be analyzed. The analyzer has a time resolution of the order of 10 ns and energy resolution close to  $\Delta E/E = 10\%$ . The high time resolution was achieved by reducing the dimensions of the stripper chamber and ion analyzer. The transit length in the analyzer was reduced by using flexible fiber optics to carry the light signal from the scintillators to the photomultipliers, FEU-16's with gain of the order of  $10^6$ . This arrangement enabled separation of the photomultiplier module from the analyzer proper, so that the size of the secondary emission detectors and the distance between them could be reduced. Results are given from an experimental check of the analyzer with measurement of the energy distribution of ions in a fast theta-pinch produced on the UN-Phenix facility. Results show that reflected particles make up the main part of the high-energy portion of averaged spectra in the ion component of a plasma produced by pulse processes of short duration. The authors thank V. L. Masalov and A. A. Shishko for assistance with the experiment. Figures 3; references 9: 6 Russian, 3 Western.

USSR

UDC 621.394.64

EXPERIMENTAL STUDIES OF THE DYNAMICS OF A NANOSECOND BEAM IN A LINAC

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 5, May 78 pp  
972-976 manuscript received 10 Mar 77

BATYGIN, YU. V., GRISHAYEV, I. A., DOVBNYA, A. N., IVANOV, G. M., KARASEV,  
S. P., KRIVONOS, A. L. and MAKHNENKO, L. A.

[Abstract] Experimental studies are done on the particle dynamics of an intense electron beam of nanosecond duration in the wave buncher and iris waveguide section of the main part of a linac. The processes of beam formation were studied in the injector of the LUE-300 linac. When the pulse duration falls to about 3.8 ns, there is an appreciable increase in the average losses of energy to the bunched beam, which is attributed to the influence of higher passbands of the iris waveguide. An expression is derived for energy losses to electron radiation in a linac in the short-pulse mode where the charged particle bunches have finite longitudinal dimensions. Calculations by this formula with consideration of excitation of higher modes of the accelerating structure agree with the results of measurements within about 16% (some overstatement of the calculated losses can be attributed to the use of a "cavity" waveguide model). In conclusion the authors thank B. A. Ponomarenko for assistance with the experiments. Figures 3; references 15: 10 Russian, 5 Western.

USSR

GENERATION OF STRESS WAVES IN A METAL BY ELECTRONS EXCITED BY NUCLEAR FISSION PRODUCTS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 20 No 7, Jul 78 pp 2222-2223  
manuscript received 24 Jan 78

BORIN, I. P.

[Abstract] Most of the kinetic energy of nuclear fission products in a metal is transmitted by electrons, whose temperature near the trajectory of a decelerating fission product rises much above the lattice temperature. The lattice temperature rises subsequently, as a result of heat conduction, and local heating of the lattice produces dynamic thermal stresses. The effect of electron pressure can be regarded as that of a "momentary impact" and, accordingly, the wave equation is solved here to yield the supersonic shear intensity in terms of the difference between radial and tangential

stresses. Structural changes in the crystal lattice, such as dislocations and defects resulting in acoustic emission, attributable to nuclear fission products can be evaluated on this basis. References 10: 7 Russian, 3 Western.

USSR

#### DYNAMICS OF LASER-DRIVEN IMPLOSION OF SHELL TARGETS

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 28 No 3, 5 Aug 78 pp 135-139 manuscript received 21 Jun 78

BASOV, N. G., VOLOSEVICH, P. P., GAMALIY, YE. G., GUS'KOV, S. YU., ZAKHAREN-KOV, YU. A., KROKHIN, O. N., ROZANOV, V. B., SKLIZKOV, G. V. and SHIKANOV, A. S., Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The compression of gas-filled spherical microshells, with diameters ranging from 75 to 125  $\mu\text{m}$  and thicknesses ranging from 0.90 to 2.25  $\mu\text{m}$ , by laser radiation of intensities up to  $10^{14} \text{ W/cm}^2$  had been measured on the "Kal'mar" facility and the results recorded in the form of radius-time diagrams. The experiment was then numerically simulated according to the hydrodynamic model with quasi-classical heat conduction. Accordingly, collapse of a shell occurs 0.1-0.15 ns after its radius has been reduced to the minimum. The close agreement between the calculated and the measured dependence of compression time on target and laser pulse parameters confirms the validity of this model. Figures 3; tables 1; references 5 (Russian).

USSR

UDC 539.125.5

SOME PARTICULARS OF THE CURRENT DEVELOPMENT OF NEUTRON PHYSICS IN CONNECTION  
WITH THE INTRODUCTION OF NEW POWERFUL PULSED NEUTRON SOURCES

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA.  
IMPUL'SNYYE NEYTRONNNYE ISSLEDOVANIYA [Transactions of the "Order of Lenin"  
Physics Institute imeni P. N. Lebedev. Pulse Neutron Research] in Russian  
Vol 94, 1977 pp 3-9

ISAKOV, A. I.

[Abstract] The author traces the development of pulse neutron research, analyzes the development of pulsed neutron sources, and examines the possibilities for neutron and nuclear physics experiments in plasma neutron sources with emphasis on pulsed thermonuclear facilities (with inertial plasma). A criterion is proposed for evaluating such neutron sources for nuclear experiments. An analysis is made of the possibilities for neutron experiments based on sequential reactions with neutrons or with the products of primary nuclear reactions. Different kinds of thermonuclear plasma sources are compared with respect to their applicability in neutron experiments. It is shown that experimental determination of neutron transport constants in matter can serve as a beginning for the design and construction of reactors and other nuclear facilities without waiting for the final measurements of all necessary differential constants. It is concluded that the development of neutron physics in the near future will involve setting up powerful thermonuclear research facilities and the development of power systems that use thermonuclear facilities. The author thanks N. G. Basov for interest in the work and constructive criticism, and also workers in the neutron physics laboratory at the Lebedev Physics Institute, Yu. A. Merkul'yev, L. A. Krupinina and Ye. R. Rychkova for assistance in preparing the bibliography and the table. References 40: 18 Russian, 4 Polish, 18 Western.

USSR

UDC 539.125.5:621.039.66

NEUTRON DIAGNOSIS OF A DENSE THERMONUCLEAR PLASMA

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA.  
IMPUL'SNYYE NEYTRONNNYE ISSLEDOVANIYA [Transactions of the "Order of Lenin"  
Physics Institute imeni P. N. Lebedev. Pulse Neutron Research] in Russian  
Vol 94, 1977 pp 10-20

GAMALIY, YE. G., GUS'KOV, S. YU. and SOBOLEVSKIY, N. M.

[Abstract] An examination is made of the following problems in neutron diagnosis: 1) the influence that the finite time of existence of the plasma has on the width of the neutron spectrum, and consideration of this effect in evaluating ion temperature; 2) the possibility of determining the temperature and density of ions in the core of a laser implosion target with respect to neutrons of DT reactions; 3) the possibility of determining the degree of compression of a laser implosion target from distortion of the spectrum of thermonuclear neutrons due to scattering in the target. It is found that the relative number of neutrons that undergo scattering is uniquely related to optical thickness with respect to the radius of the target. In addition, the uncertainty in knowledge of the shape of the source introduces an error of no more than 30%. This enables evaluation of the average density of the core of the target from measurement of the low-energy tail of the spectrum of thermonuclear neutrons. Figures 6; references 14: 10 Russian, 4 Western.

USSR

UDC 539.1.074.8

DETECTORS FOR NEUTRONS FROM A SHORT-LIVED PLASMA

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA.  
IMPUL'SNYYE NEYTRONNNYE ISSLEDOVANIYA [Transactions of the "Order of Lenin"  
Physics Institute imeni P. N. Lebedev. Pulse Neutron Research] in Russian  
Vol 94, 1977 pp 21-28

VOLOBUYEV, I. V., GORBUNOV, D. N., GRANATKIN, B. V. and ISAKOV, A. I.

[Abstract] The paper describes detectors that are used at the Lebedev Physics Institute for neutron diagnosis of plasma. These are highly sensitive scintillation detectors with efficiency of up to 45%. The diffusion parameters of thermal neutrons are measured in polystyrene and white spirit as a basis for calibrating detectors with the corresponding scintillators. Activation counters are described for recording the yield beginning with  $5 \cdot 10^4$

neutrons per flash. The authors thank N. G. Basov, O. N. Krokhin, A. V. Antonov, O. G. Ryazhskaya, A. A. Tikhomirov and Ye. N. Volkov for discussion of the problem and assistance with the work. Figures 5; references 13 (Russian).

USSR

UDC 621.378.9

#### LASER-FUSION TARGETS

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA. IMPUL'SNYYE NEYTRONNYYE ISSLEDOVANIYA [Transactions of the "Order of Lenin" Physics Institute imeni P. N. Lebedev. Pulse Neutron Research] in Russian Vol 94, 1977 pp 29-60

GAMALIY, YE. G., GROMOV, A. I., ISAKOV, A. I., KRUPININA, L. A., LEONOV, YU. S., MATVEYEVA, F. I., MERKUL'YEV, YU. A., NIKITENKO, A. I., RYCHKova, YE. R. and SKLIZKOV, G. V.

[Abstract] Experimental and theoretical research has shown that the maximum compression and heating of the matter in laser driven fusion can be achieved only in the case of spherically symmetric action on the target, which in the optimum version is a complex multilayered structure. The authors discuss general problems of laser target technology, methods of automatic preselection and sorting of microspheres, the ideal diagnostic layers of material, methods of making multilayered shells and techniques for checking target parameters. The paper is based on research at the Lebedev Physics Institute in the neutron physics laboratory in cooperation with the laboratory of quantum radiophysics. The requirements for target parameters that arise from current theoretical concepts are presented. The technological possibilities for making more complicated and efficient targets are discussed as well as ways to improve the parameters of existing targets by special treatment or the application of special layers. Various methods of laser plasma diagnosis are discussed that are based on the use of special targets and suspension systems. The authors thank N. G. Basov and O. N. Krokhin for continued interest and support of the work as well as constructive criticism, Yu. V. Afanas'yev and V. B. Rozanov for useful advice, Yu. A. Mikhaylov and S. I. Fedotov for assistance, and R. N. Traktirnikov and Ye. N. Ochkayev for preparing the equipment and taking part in some experiments. Figures 26; references 50: 18 Russian, 7 Polish, 25 Western.

USSR

UDC 539.125.5

## EXPERIMENTS WITH ULTRACOLD NEUTRONS

Moscow TRUDY ORDENA LENINA FIZICHESKOGO INSTITUTA IMENI P. N. LEBEDEVA.  
IMPUL'SNYYE NEYTRONNNYE ISSLEDOVANIYA [Transactions of the "Order of Lenin"  
Physics Institute imeni P. N. Lebedev. Pulse Neutron Reactors] in Russian  
Vol 94, 1977 pp 73-101

ANTONOV, A. V., ISAKOV, A. I., KOVYL'NIKOV, V. N., LIN'KOVA, N. V.,  
MIKEROV, V. I., STARTSEV, S. A., PEREKRESTENKO, A. D. and TIKHOMIROV, A. A.

[Abstract] An interesting peculiarity of ultracold neutrons with energy of the order of  $10^{-7}$  eV is their property of total reflection from media with positive amplitude of coherent scattering. The authors consider this group of neutrons with energy below some limit for the given medium that are totally reflected at the interface between the medium and vacuum for any angles of incidence. The limiting energy for matter is defined by the expression  $E_{\text{lim}} = \frac{b^2}{2Nm} N_{\text{coh}}$ , where  $m$  is the mass of a neutron,  $N$  is the number of atoms of matter in a unit of volume and  $b_{\text{coh}}$  is the length of coherent scattering of a neutron by a bound nucleus. Various aspects of the physics of this group of particles are considered: ultracold neutron detectors (the uranium-titanium radiator, track detector, semiconductor counter and gas scintillation detector, and also a scintillation detector with silver-activated zinc sulfide phosphor and uranium-titanium layer); preliminary experiments with ultracold neutron traps on steady-state and pulse reactors; interaction of ultracold neutrons with potential alternating in space; transmission of ultracold neutrons through a vibrating membrane; some optical systems, including the feasibility of using lenses in ultracold neutron spectrometers. Figures 25; references 57: 37 Russian, 1 Bulgarian, 19 Western.

USSR

UDC 539.1.074

A NEW PARTICLE DETECTOR--A SPARK COUNTER WITH LOCALIZED DISCHARGE

Moscow IZVESTIYA AKADEMII NAUK SSSR, SERIYA FIZICHESKAYA in Russian Vol 42,  
No 7, Jul 78 pp 1488-1490

LAPTEV, V. D., PESTOV, YU. N., PETROVYKH, N. V., SANNIKOV, B. P. and  
FEDOTOVICH, G. V., Institute of Nuclear Physics, Siberian Department,  
Academy of Sciences USSR

[Abstract] The authors describe a new kind of particle detector--a flat-spark counter with localized discharge. In contrast to conventional plane-parallel spark counters, this device makes use of a material with high resistivity ( $10^9$ - $10^{10}$  ohm.cm) as one of the counter electrodes, and the inter-electrode gap is filled with a gas mixture that absorbs photons from the spark. As a result, at the instant of breakdown the fixed voltage applied to the counter plates is taken off from a limited region of the electrodes near the discharge. This localization of the discharge eliminates the size limitation inherent in conventional spark counters, where increasing the size causes a rise in energy released during breakdown, resulting in electrode damage. The proposed design also increases count rate since discharge localization makes the device equivalent to a large number of independent spark counters. Analysis of experimental data shows that time resolution of a single counter is about 28 ns, assuming gaussian distribution. Accuracy of coordinate location is about 0.1 mm, which is on a level with other types of modern spark counters. The data output of the counters is convenient for on-line operation with a computer. The authors thank A. M. Budker, L. M. Barkov and A. N. Skrinskiy for interest in the work, N. G. Bayev, T. V. Oslopova and M. I. Osokin for assistance in preparing the equipment, and A. I. Romanchuk for design developments. Figures 2; references 10: 8 Russian, 2 Western.

Optics and Spectroscopy

USSR

UDC 535.411:533.605

USING A POLARIZATION INTERFEROMETER IN A BALLISTIC EXPERIMENT

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 46 No 7, Jul 78 pp 1457-1461 manuscript received 4 Jul 77

KOMISSARUK, V. A., KOVALEV, P. I., MARTYNOV, V. P. and MENDE, N. P., Physico-technical Institute imeni A. F. Ioffe, Academy of Sciences USSR, Leningrad

[Abstract] The authors describe the use of a polarization interferometer in a ballistic experiment to study the flow around models in free flight. The instrument is based on the series-produced IAB-451 shadow camera. Wall-aston prisms are installed in place of the slit and knife of the instrument. The band curvature caused by placing crystal elements in the converging beams is corrected by half-wave plates. The light source is an OGM-20 laser with scatterers. The optics of the installation were adjusted to maximize the contrast of the interference patterns. Examples of interferograms are given, and the results of processing are compared with numerical calculations. It is concluded that interference measurements by polarization interferometry are highly accurate in ballistic experiments. Figures 5; references 8: 7 Russian, 1 Western.

USSR

UDC 621.378.33+535.89

HYBRID MODES IN RADIATIVE DISTRIBUTED FEEDBACK STRUCTURES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1057-1064 manuscript received 27 May 77

PROKHOROV, A. M., SPIKHAL'SKIY, A. A. and SYCHUGOV, V. A., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] Formulas have been derived in previous research for numerical analysis of the process of reflection of surface light waves on a corrugated section of a waveguide with measurement of the mode index  $m$  (where  $m = 1, 2, 3\dots$ ). This paper gives expressions in explicit form for coefficients of reflection, emission and transmission of H-waves and E-waves on a corrugated section of a thin-film and diffusion waveguide in the general case; on the basis of these expressions, a further analysis is made of the process of reflection of so-called hybrid (mixed) modes. Analysis of the process of reflection and conversion of a surface light wave on a waveguide section with corrugation period of the order of  $\lambda/n^*$  (the ratio of the vacuum wavelength of the light to the effective index of refraction) demonstrates the feasibility of making a narrow-band frequency filter that operates on transmission.

The maximum transmission factor of such a filter increases with the ratio  $q_{m2}/q_{m1}$  (reflected-to-incident damping factor), and the bandwidth decreases with increasing  $q_{m2}k\ell$  (where  $\ell$  is the length of a corrugation). Despite the necessity for wave reflection, the optimum transmission of the frequency filter is realized for a low reflection factor. Figures 4; references 9: 7 Russian, 2 Western.

USSR

UDC 621.378.325

#### THE USE OF LASERS IN MODULATION SPECTROSCOPY

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 6, Jun 78 pp 1329-1340  
manuscript received 28 Jun 77

AKHMANOV, S. A., GOLYAYEV, YU. D. and LANTRATOV, S. V., Moscow State University imeni M. V. Lomonosov

[Abstract] This article is dedicated to the analysis of the resolution and sensitivity of laser modulation spectroscopy for two main types of lasers: a laser with strongly inertial nonlinearity, on the example of a garnet laser with neodymium doping, and a laser with low inertia of nonlinearity, on the example of a gas He-Ne laser. The use of lasers with high spectral brightness of radiation and a low noise level can significantly increase the sensitivity of modulation spectroscopy. The use of a solid-state laser improves sensitivity in intracavity modulation spectroscopy by a factor of 10-50 for a photodiode and by a factor of  $10^3-10^4$  for a photomultiplier as compared with the extracavity method. Another advantage of the use of lasers is the possibility of developing new systems of measurement, particularly those using nonlinear transformations of light. Figures 6; tables 1; references 14: 12 Russian, 2 Western.

USSR

UDC 539.186.2+541.124.7:535

METHOD OF COLLISION PHOTOIONIZATION SPECTROSCOPY OF RADIATION AND AN INSTRUMENT FOR ITS PERFORMANCE

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 44 No 6, Jun 78 pp 1076-1085 manuscript received 19 Dec 77

MISHCHENKO, YE. D., ABDULLAYEV, A. M., KAZACHEVSKAYA, T. V. and KVATER, G. S.

[Abstract] The possibility was analyzed of using known photoionization spectrometers for radiation spectroscopy. It was found that the primary factor limiting their broad application is the low threshold sensitivity. This article discusses a method of collision photoionization spectroscopy of radiation in which the quantum sensitivity is increased by several orders of magnitude. The quantum sensitivity at the 584 Å wavelength is  $2.1 \cdot 10^{-3} \text{ e}^{\pm} \cdot \text{cm}^2 \cdot \text{s} / \text{kV}$ , allowing reliable recording of  $10^5 \text{ kV/cm}^2 \cdot \text{s}$ . A simplified drawing is presented of the design of the new instrument. Figures 3; table 1; references 9: 8 Russian, 1 Western.

USSR

UDC 621.315.592

SOME PROBLEMS OF PHOTOELECTRIC SPECTROSCOPY

Moscow IZVESTIYA AKADEMII NAUK SSSR, SERIYA FIZICHESKAYA in Russian Vol 42, No 6, Jun 78 pp 1122-1130 paper presented at the First All-Union Seminar on Photoelectric Spectroscopy of Semiconductors 23-25 May 77

KOGAN, SH. M. and LIFSHITS, T. M., Institute of Radio Engineering and Electronics, USSR Academy of Sciences

[Abstract] Photoelectric spectroscopy refers, in the narrow sense, to line spectra of photoconduction. The main problem here is measurement of the photothermal ionization effect and determination of its probability. The outstanding sensitivity of this method has made it very suitable for identification of residual impurities in pure and hyperpure semiconductors, at low temperatures or at higher temperatures, possibly with the application of strong and variable magnetic fields. Photoelectric spectroscopy is also becoming the preferred method for identification of trace impurities in gases. Figures 5; references 25: 17 Russian, 8 Western.

USSR

UDC 535.34:551.51

ABSORPTION SPECTRUM OF THE ATMOSPHERE OVER THE 583-605 nm RANGE AS MEASURED BY THE METHOD OF INTRACAVITY LASER SPECTROSCOPY

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 45 No 1, Jul 78 pp 58-63  
manuscript received 12 Jul 77

BAYEV, V. M., BELIKOVA, T. P., IPPOLITOV, M. B., SVIRIDENKOV, E. A. and SUCHKOV, A. F.

[Abstract] Intercavity laser spectroscopy makes it feasible to accurately identify the absorption spectrum of air by elimination of the masking effect of solar absorption lines in sunlight. The sensitivity of this method was improved to a record  $3 \cdot 10^{-9}$  cm<sup>-1</sup> by using as the source a laser jet of rhodamine 6G dye dissolved in ethylene glycol, oriented at the Brewster angle to the optical axis of a resonator cavity between two concentric reflectors. The absorption spectrum of laboratory air was scanned over the 583-605 nm range of wavelengths and, as a result, many new lines were discovered which sunlight would not reveal. Their intensity exceeds that of some already known ones. These lines are probably attributable to impurities in the air and, in fact, 28 of them have been identified as those of NO<sub>2</sub>. Figures 2; references 9: 7 Russian, 2 Western.

USSR

UDC 621.373:535

EMISSION LOSSES OF A PHOTODISSOCIATION LASER DUE TO OPTICAL INHOMOGENEITIES IN THE ACTIVE MEDIUM

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 45 No 1, Jul 78 pp 140-146  
manuscript received 11 Oct 77

DANILOV, O. B., ZHEVLAKOV, A. P. and YACHNEV, I. L.

[Abstract] A study was made to determine the effect of optical inhomogeneities in the active medium on the emission losses in the case of a photodissociation laser on perfluoralkyl iodides CF<sub>3</sub>I or n-C<sub>3</sub>H<sub>7</sub>I and their mixtures with sulfur hexafluoride SF<sub>6</sub>. Recorded changes in near-field and far-field interferograms indicate a minor role of chemical processes in changing the refractive index. They also indicate that gradients of the refractive index cause shifting and discontinuity of fringes. As the cavity length increases, at a constant pumping intensity and a constant gas pressure, the emission energy has been found to decrease to an eventually constant level. Introducing a coefficient of spurious losses proportional to the square-root of

the cavity length brings into close agreement the results of emission power measurements by the cavity calibration method and computer-aided calculations based on a theoretical kinetic model of a photodissociation laser with an optically thin medium. The authors thank V. Yu. Zalesskiy for the useful comments and A. M. Kokushkin for performing the computer calculations. Figures 4; tables 1; references 17: 16 Russian, 1 Western.

USSR

UDC 535.33/.34:548.0

OPTICAL SPECTRA AND MULTIFREQUENCY RADIATION OF STIMULATED EMISSION FROM  
LiYF<sub>4</sub>-Er<sup>3+</sup> CRYSTALS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 45 No 1, Jul 78 pp 147-155  
manuscript received 10 Aug 77

PETROV, M. V. and TKACHUK, A. M.

[Abstract] Crystals of binary yttrium-lithium fluoride LiYF<sub>4</sub> have a tetragonal scheelite form and, when activated with a rare-earth ion such as Er<sup>3+</sup>, they become sources of luminescence or laser media. Their optical emission and absorption spectra were measured at 77 and 300 K, also the lifetimes of their lowest terms, to verify the band structure of terms and transitions. Stark-effect splitting was produced experimentally and, subsequently, radiation of stimulated emission at  $^4S_{3/2} \rightarrow ^4I_{9/2}$  ( $\sim 1.7 \mu\text{m}$ ),  $^4S_{3/2} \rightarrow ^4I_{11/2}$  ( $\sim 1.2 \mu\text{m}$ ),  $^4S_{3/2} \rightarrow ^4I_{13/2}$  ( $\sim 0.85 \mu\text{m}$ ),  $^4I_{11/2} \rightarrow ^4I_{13/2}$  ( $\sim 2.9 \mu\text{m}$ ) transitions, also simultaneous multifrequency and sequential radiation of emission at several of these transitions. Furthermore, the temperature dependence of the threshold pumping energy has been established with the aid of a selective resonator cavity. Figures 4; tables 4; references 30: 8 Russian, 22 Western.

USSR

UDC 621.373:535

LONGITUDINAL MODE-LOCKING IN AN ARGON LASER IN A THREE-REFLECTOR CAVITY

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 45 No 1, Jul 78 pp 191-193  
manuscript received 17 Jan 77

KOROLEV, F. A., SALIMOV, V. M. and TSURIKOVA, M. V.

[Abstract] Stable longitudinal self-mode locking in an argon laser operating at the  $\lambda = 4880 \text{ \AA}$  wavelength occurs only near the self-excitation threshold. With a multireflector cavity, however, it has been found possible to track emission pulses at a higher repetition rate. In this study a three-reflector cavity was considered for self-locking farther away from the threshold. Experimental data as well as numerical estimates of the pull-in, the pull-in nonlinearity, and the phase lead indicate that such a self-locking depends on narrowing the emission band, which can be achieved with the aid of an appropriately designed Fabry-Perot interferometer. It is thus feasible to produce a source of periodic nanosecond light pulses. Figures 1; references 9: 4 Russian, 5 Western.

USSR

UDC 621.391.63

APPROXIMATE CALCULATION OF THE TRANSMISSION COEFFICIENT FOR FIBER OPTICS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 45 No 1, Jul 78 pp 195-196  
manuscript received 16 May 77

LAVRINOVICH, B. M.

[Abstract] A conical bundle of fibers is considered, all fibers of given diameter, length, and aperture angle being made of a material characterized by a refractive index, a natural absorptivity, and a coefficient of total reflection. The theoretical transmission coefficient for such a bundle is expressed in the form of an integral, as a function of all other parameters, according to the laws of optics. It can be evaluated numerically either with the aid of a computer or by the Simpson rule. Here a simple approximate formula is shown, based on the fact that the optical characteristics of most fiber materials fall within certain ranges. Its error is within 5% and approaches zero at aperture angles smaller than  $5^\circ$ . With the transmission coefficient known beforehand, conversely, this formula can be used for determining the natural absorptivity and the coefficient of total reflection from two measurements, each at a different aperture angle, and the resulting two equations with two unknowns. With a sufficiently large aperture

angle, according to this formula, the luminous flux at the fiber exit exceeds the maximum luminous flux from a diffuse source. This critical angle, a characteristic parameter of a fiber, is the optimum aperture angle and angles larger than that will not further increase the luminous output.  
References 2 (Russian).

USSR

UDC 535.3+539.238

EXPERIMENTAL STUDY OF PHASE DISTRIBUTIONS ALONG THE RADIATING APERTURE OF A THIN-FILM OPTICAL WAVEGUIDE

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 45 No 1, Jul 78 pp 182-186  
manuscript received 20 Jun 77

ZAYTSEV, S. V., KUZALI, A. S. and CHEKAN, A. V.

[Abstract] Phase distributions along the radiating aperture of a thin-film optical waveguide were studied experimentally, to determine the effect of manufacturing precision on the radiation characteristics of such a waveguide. Interference measurements with a coherent light source ( $TE_0$ -mode at the  $\lambda = 0.6328 \mu\text{m}$  wavelength) and a beam splitter were made within the near-field zone of a waveguide, the latter consisting of a polystyrene film on a glass substrate with a holographically deposited diffraction grating (period  $T = 0.6 \mu\text{m}$ ). As a result, a relation has been established between the nonlinearity of a phase distribution, i.e., the phase error in the aperture and the decrease of the effective aperture length or the broadening of the radiation pattern. An analysis of this relation indicates that, as the phase error builds up along a waveguide, the interference method of checking the thickness of thin films for uniformity becomes more sensitive. The authors thank L. N. Deryugin for the useful discussion of the results. Figures 4; references 3 (Russian).

USSR

UDC 535.337

EXPERIMENTAL STUDY OF THE EMISSIVITY SPECTRUM OF QUARTZ GLASS AT HIGH TEMPERATURES

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 16 No 4, Jul/Aug 78  
manuscript received 25 Jan 78

DVURECHENSKIY, A. V., PETROV, V. A., and REZNIK, V. YU., Institute of High Temperatures, USSR Academy of Sciences

[Abstract] The normal emissivity of grade KV quartz glass, over the 2-5.5  $\mu\text{m}$  range of wavelengths, was measured by comparison with a black body and with a pyrometer at four temperatures: 673, 1073, 1473, and 1673 K. Specimens 1.96, 6.0, and 10.16 mm thick with optically smooth surfaces were placed under vacuum ( $5 \cdot 10^{-5}$  mm Hg) and heated by the fast high-frequency method. The emissivity at all these temperatures was found to peak narrowly at the  $\lambda = 2.75 \mu\text{m}$  wavelength, this peak emissivity increasing with the specimen thickness, and then to saturate to 0.97 at wavelengths above  $\lambda = 4.8 \mu\text{m}$ . The authors thank O. D. Dmitrievskiy for the help in setting up the high-speed IKS-20 spectrometer and G. Yu. Levenfel'd for the assistance and continuous interest. Figures 3; tables 1; references 24: 12 Russian, 12 Western.

USSR

UDC 535.8

ANALYZING THE CHARACTERISTICS OF ASPECTROGRAM SPECTRA

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 8, Aug 78 pp 1689-1695 manuscript received 24 Nov 77

DAVYDOVA, I. N.

[Abstract] An experimental study was made to confirm the feasibility of performing various operations such as image multiplication by means of filtering masks. A spectrum analyzer with minimum aberration was built for this purpose, consisting of two identical aerial objective lenses placed back-to-back. Sparse aspectograms, with appropriate foreshadowing, of a radial halo were photographically recorded through it. The results are evaluated in terms of energy and intensity, depending on the mask geometry and optics, also in terms of resolving power as a function of the iris size and peak width as a function of the aspectogram width. Calculations are based on theoretical relations for a halo with a bounded intensity step resulting in the equation of an equilateral hyperbola. Figures 8; references 3 (Russian).

USSR

CORRECTION OF NONLINEAR MODULATION DISTORTIONS IN ACOUSTO-OPTICAL TELEVISION SYSTEMS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 46 No 7, Jul 78 pp 1446-1448 manuscript received 13 Sep 77

SHAPIRO, L. L. and SHUSTAREV, D. YU.

[Abstract] It is shown that the use of diffraction of optical radiation by hypersonic waves in laser television introduces difficulties in proper transmission of brightness gradations in reception and linear amplification of the video signal because of the way that diffraction intensity depends on the amplitude of the controlling voltage. The resultant modulation distortions can be corrected by changing the shape of the video signal at the input to the acousto-optical modulators of the brightness (luminous flux intensity) of laser emission. It is shown that the amplitude characteristic for determination of the transfer function of the correcting filter must be found by experimental analysis. Experiments using this procedure to design a correction element with nonlinear load in the emitter circuit showed that such a filter can correct gradation distortions in an acousto-optical television system. Figures 3; references 5: 3 Russian, 2 Western.

USSR

UDC 536.5.087.92

A DEVICE FOR CALIBRATING INFRARED TELEVISION EQUIPMENT

Moscow IZMERITEL'NAYA TEKHNIKA in Russian No 6, Jun 78 pp 31-32

SHOLOKHOV, V. A. and MOROZOV, P. A.

[Abstract] A device is described for calibrating and checking the stability of infrared television equipment that picks up a minimum temperature difference in an object in a range of 0.2-0.4°C. The device consists of two radiators with built-in thermocouple converters, and an electronic system for setting and stabilizing the temperature of the radiators. The radiators are heated to the set temperature by current passed through nichrome windings situated along the graphite bodies of the radiators. The temperature of one of the graphite bodies is time-stabilized by thermocouple converters in the housing of the radiator and a DC adjustable electronic system. The temperature of the second radiator exceeds the temperature setting by a fixed differential, and is stabilized by an AC electronic adjustable system and two thermocouple converters in the housings of the radiators. The

second radiator is heated by current flowing directly through the graphite body. This reduces fluctuations due to heat lag with change in the ambient temperature. A schematic diagram of the device is given as well as a diagram of the radiator. Figures 2.

USSR

UDC 621.397.61:539.12.074

ANALYSIS OF THE SPACE-FREQUENCY CHARACTERISTICS OF OPTOMECHANICAL ANALOGS OF A TRANSMITTING TELEVISION CAMERA

Moscow IZMERITEL'NAYA TEKHNIKA in Russian No 6, Jun 78 pp 29-31

MALYSHEVA, T. P., MOROZOVA, S. P. and MOROZOV, P. A.

[Abstract] Optomechanical scanning devices with quasipoint radiation detector are considered as instruments for producing infrared and heat images. These devices are divided into those with scanning in the space of objects, and with scanning in the space of images. In the former case, the radiation of elements of the object is directed by the scanning device to a narrow-field objective lens that focuses the radiation on a receiver. In the latter case, the entire field of analysis is incident on a wide-field objective lens. The scanning device directs radiation from separate elements of the image to the receiver. In this article, the authors consider the image quality of a high-speed infrared television camera with scanning device in the space of the image (AGA-661, BTV-1, ITP-1). The influence of scanning elements on image quality is considered in an optical arrangement with focusing mirror in the form of a parabolic or spherical surface, and the space-frequency characteristics of such a system are examined. Analysis shows that it is preferable to use a parabolic surface as the focusing element. Even in this case, corrections must be made for the fall-off in contrast at the edges of the image when the total field of view is used. Figures 5; references 3: 2 Russian, 1 Western.

USSR

UDC 621.396.2

PROPAGATION OF MODULATED WAVES IN A TURBULENT ATMOSPHERE. II. CORRELATION FUNCTIONS AND FREQUENCY SPECTRUM OF PHASE FLUCTUATIONS OF THE MODULATING WAVEFORM

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1124-1129 manuscript received 20 Jun 77

LUKIN, V. P. and LUKIN, I. P., Institute of Optics of the Atmosphere, Siberian Department of the Academy of Sciences USSR, Tomsk

[Abstract] The authors discuss the principle of modulating a laser signal in optical communication by using an auxiliary harmonic waveform rather than by acting directly on the useful signal with a carrier wave. This considerably reduces the level of noises introduced by ground turbulence of the atmosphere. An analysis is made of the statistical characteristics of phase fluctuations of the modulating signal--space and time correlation functions and the time frequency spectrum that is associated with them--in the smooth perturbation approximation. It is shown that the phase transmission error behaves statistically on the whole like the fluctuations in the phase of the carrier wave. The width of the frequency spectrum is of the order of  $v/L_0$ , where  $v$  is the average transverse wind speed and  $L_0$  is the external scale of turbulence. Figure 1; references 7: 6 Russian, 1 Western.

USSR

UDC 621.373.826:621.396

PHOTOCELLS AND DIFFRACTION GRATINGS OF RELIEF TYPE IN THIN FILMS OF  $\text{As}_2\text{S}_3$  FOR INTEGRATED OPTICS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1090-1094 manuscript received 28 Apr 77

ANDRIYESH, A. M., BYKOVSKIY, YU. A., SMIRNOV, V. L., CHERNIY, M. R. and SHMAL'KO, A. V., Moscow Engineering Physics Institute, Institute of Applied Physics of the Moldavian Academy of Sciences, Kishinev

[Abstract] An investigation is made of the possibilities for constructing combined photoreception-registration integrated optics elements and making relief type diffraction grating structures on the surface of thin-film waveguides on the basis of amorphous chalcogenide semiconductors in the As-S-Se system for purposes of integrated optics. Thin  $\text{As}_2\text{S}_3$  films were prepared by sputtering in a vacuum on glass and lithium niobate substrates.

Relief diffraction gratings were produced on the surface of the resultant waveguides by exposure to laser emission on wavelengths of 0.4416 and 0.5145  $\mu\text{m}$  and development of the resultant interference pattern in NaOH. The profile of the interference bands was close to sinusoidal. These gratings can be used in thin-film waveguides for radiation coupling and mode conversion. Figures 5; references 11: 8 Russian, 3 Western.

USSR

UDC 621.396:535.8

THE TRANSVERSE ELECTRO-OPTICAL EFFECT IN A MATRIX-ADDRESSABLE TRANSPARENCY BASED ON LATHANUM-DOPED LZT CERAMIC

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1034-1042 manuscript received 25 May 77

BAKUNOVA, T. I., KOMPANETS, I. N., LEVICHEV, A. S., SEMOCHKIN, P. N., SMOLYA, A. V., SOBOLEV, A. G. and FEL'DMAN, N. B., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] The transverse electro-optic effect has not been used in matrix-addressable electrically controlled transparencies because of the problems associated with electrode geometry. In this paper the authors demonstrate the feasibility of using the transverse electro-optical effect in a matrix-addressable transparency based on lanthanum-doped lead zirconate-titanate (PLZT) ceramic. A low-amplitude alternating electric field is used to erase recorded information. Electrodes of special configuration ensure a considerable electric field vector in the plane of the transparency, and dielectric films in the form of strips suppress the edge effect where the electrodes cross in space. The technique for making the transparency is somewhat complicated, but this is compensated by the considerable gain in efficiency of electro-optic conversion with respect to light (50% or more) as compared with electrically controlled transparencies based on the edge effect. The erasure method increases optical contrast beyond 100:1 in the matrix addressing mode. The speed of the transparency is determined mainly by the duration of the erasure process. It should be possible to make matrix-addressable transparencies by the proposed technique that operate at a rate of 10 cycles per second. The authors thank Yu. P. Zakharov for assistance in making the transparencies. Figures 8; references 8: 3 Russian, 5 Western.

USSR

UDC 681.327.2.082.5:778.38

INVESTIGATION OF THE RELIABILITY OF DATA READOUT BY AN OPTOELECTRONIC CHANNEL IN A HOLOGRAPHIC MEMORY

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 995-999  
manuscript received 3 Jun 77

AKSEL'ROD, A. A., BOBRINEV, V. I., VORONIN, V. G., SMIRNOV, S. V. and STROMILOV, I. S.

[Abstract] An examination is made of problems of reliability of data readout in an isolated channel of a holographic memory. The information was recorded by data files in binary code on a photographic plate. A bright point corresponded to the "1" state, and a dark field corresponded to the "0" state. The readout channel was made up of an image-converter tube, a photomultiplier, an amplifier, an integrator and a threshold device. Image reconstruction was by a helium-neon laser. The real image of the hologram was reconstructed on the photocathode of the image-converter tube. Energy per bit on the photocathode was  $10^{-15}-10^{-14}$  J for readout time of about  $10^{-6}$  s. An approximate expression is derived for the low probability of malfunctions as a function of the contrast between "1" and "0" and the ratio of the signal to rms fluctuation, assuming that the laser emission conforms to Poisson statistics. Curves are plotted for the probability of failures as a function of these parameters, and also as a function of the threshold stability and signal level in the readout channel. Experiments with alternating readout of "1" and "0" in a single channel for one hour showed no errors. As the clock frequency was  $5 \cdot 10^5$  Hz, the probability of malfunctions was no greater than  $5 \cdot 10^{-10}$ . The ratio of signal to fluctuation was about 15, and contrast was about 20. Figures 5; references 3 (Russian).

USSR

UDC 535.317

POLARIZATION HOLOGRAMS IN REFLECTED LIGHT

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 6, Jun 78 pp 1310-1311 manuscript received 10 May 77

KAKICHASVILI, SH. D., Institute of Cybernetics, Academy of Sciences of the Georgian SSR, Tbilisi

[Abstract] Photoinduced anisotropy in reflected light (the Weigert effect) in aluminoborosilicate photochromic glass is used in recording polarization Lippmann holograms. The radiation source was a helium-neon laser, and the plates were preactivated by ultraviolet light. The reference wave was

linearly polarized. The scalar-to-vector response of the medium was of the order of 9. Distortions due to simultaneous scalar and vector response of the Weigert medium can be eliminated by recording in a holographic arrangement where the reference and object waves meet at an angle of 90°, the reference wave is linearly polarized, and the plane of vibration of its electric vector is in the direction of the object beam. Experiments with this arrangement gave a high-quality image. Figures 2; references 16: 10 Russian, 6 Western.

USSR

UDC 621.378.35

USE OF GRADED-INDEX LIGHT GUIDES TO MATCH INJECTION LASERS WITH OPTICAL FIBERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 6, Jun 78 pp 1237-1243  
manuscript received 28 Dec 77

MIRONOV, YU. M. and SEMENOV, A. S., Institute of Physics imeni P. N.  
Lebedev, Academy of Sciences USSR, Moscow

[Abstract] It is suggested that the radiation pattern of a laser be matched with single and multiple-mode fibers by means of graded-index light guides with square-law variation in the index of refraction. These light guides have a number of interesting properties, making them very promising for use in optical information processing systems. They include their lens-like properties, allowing transmission of an optical image which is focused in planes periodically located along the axis of the fiber, as well as their reduced wavelength dispersion in comparison to multi-mode step-index fibers. The graded-index light guide allows the coupling factor to be increased by 1.5-3.5 times in comparison to direct connection between laser and fiber, achieving coupling as high as 100%. Figures 5; table 1; references 6: 4 Russian, 2 Western.

USSR

UDC 621.391.837:621.373.826

ANALYSIS OF THE QUALITY OF LASER IMAGES OF DIFFUSE OBJECTS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 6, Jun 78 pp 1257-1262  
manuscript received 10 Jun 78

USTINOV, N. D., BAKUT, P. A., BARINOV, V. V., DEVYATKOV, L. A., MANDROSOV,  
V. I. and TROITSKIY, I. N.

[Abstract] A theoretical and experimental study is presented of the quality of the laser image of diffusely scattered objects with low optical-system resolution. The study is performed for a flat object in a plane perpendicular to the axis of the optical system. It is determined that the field scattered by a diffuse object illuminated with coherent radiation is described quite well by the normal distribution with a correlation radius less than the size of an element of resolution. The intensity in the laser image is distributed according to a negative-exponential probability density function. In the case of limited resolution of the optical system the laser image fluctuates in intensity, forming a set of a small number of bright spots, losing the geometric shape of the object. A laser image comparable in quality to the image produced with high angular resolution optics in white light can be achieved by increasing the resolution of the optical system or by using several rather widely separated wavelengths to illuminate the object, in which case the accuracy of identification of the first image with the second is approximately  $1/(NP)$ , where  $N$  is the number of wavelengths and  $P$  is the number of elements of resolution on the object. Figures 4; references 6: 3 Russian, 3 Western.

USSR

UDC 681.327.6

ASSOCIATIVE RETRIEVAL OF INFORMATION IN HOLOGRAPHIC MEMORIES WITH CONTROLLED TRANSPARENCIES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 6, Jun 78 pp 1298-1304

VASIL'YEV, A. A., KOMPANETS, I. N., KOTOVA, S. P. and MOROZOV, V. N.,  
Institute of Physics imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] This work experimentally checks the possibility of using phase-controlled transparencies to produce a set of orthogonal key words in associative memories. The functional capabilities of this method of formation and retrieval of key words and methods of realization of associative memory

units on its basis are analyzed. When a system of Walsh functions is used as the key words, the ratio of signal to retrieval noise experimentally achieved averages 150:1. Figures 3; references 12: 9 Russian, 3 Western.

USSR

UDC 535.317.1+535.818.8

OPTIMIZATION OF THE PARAMETERS OF A HOLOGRAPHIC MEMORY CONSIDERING ABERRATIONS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 44 No 6, Jun 78 pp 1163-1170 manuscript received 13 Apr 77

SOSKIN, S. I. and SHOYDIN, S. A.

[Abstract] An earlier article by one of the authors analyzed optimization of the parameters of a holographic memory considering the aberrations in the primary lenses, and produced equations defining the optimal dimensions of memory cells for the photoreceptors and holograms, as well as the dimensions of the matrices themselves. This work develops a stricter approach, based on maximization of the information capacity of the optical system of a holographic memory with assigned aberrations, signal/noise ratio and speed. Limitations related to the resolution and granularity of the recording medium, nonlinearity of recording, as well as scattering in the optical elements, are ignored. The results of the work are suitable for optimization of practically any holographic memory optical system with known aberration characteristics. A flowchart is presented for the program for optimization of the holographic memory, and it is pointed out that the optimization program can be mated to a program for automatic adjustment of aberrations for the design of a high-capacity holographic memory. Figures 3; table 1; references 11: 6 Russian, 5 Western.

USSR

UDC 621.378:535.4

AMPLIFYING DYNAMIC HOLOGRAMS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 28 No 6, Jun 78 pp 992-996

IVAKIN, YE. V., LAZARUK, A. M., PETROVICH, I. P. and RUBANOV, A. S.

[Abstract] A study is made of the possibility of using the phenomenon of saturation of amplification during the recording of dynamic holograms. In this case, the process of recording of the hologram in the inverse medium is accompanied by amplifications of the intensity of the interfering waves and simultaneous development and amplification of additional diffracting light beams (self-diffraction in the amplifying medium). Recording of a dynamic hologram in a dye solution by this method shows that it is possible to increase sensitivity by 2 orders of magnitude over levels previously achieved. Figures 4; references 5 (Russian).

USSR

UDC 772.99

RECORDING AND ERASING ON Cu-As-Se GLASSES WITH LASER LIGHT

Kiev UKRAINSKIY FIZICHESKIY ZHURNAL in Russian Vol 23 No 6, Jun 78 pp 1020-1021 manuscript received 22 Aug 77; after revision 5 Dec 77

VLASOV, V. I. and SEMAK, D. G., Uzhgorod State University

[Abstract] The feasibility of recording and erasing of optical information on  $Cu_{10}(As_2Se_3)_{90}$  layers with laser light has been established experimentally. The optical density of such a layer was found to decrease upon illumination with light from a He-Ne laser of a  $0.3\text{-}4.5 \text{ W/cm}^2$  intensity and then to increase upon illumination with such a light of a higher intensity. The optical density of this layer could be subsequently decreased and increased again by illumination with light of respectively lower and higher intensity. Multiple recording and erasing is thus possible. By changing the temperature of the glass layer, furthermore, it also becomes possible to erase with light of the same intensity and wavelength as that which has been used for recording. Both processes are completely reversible, and evidently addition of a third element (copper) to the As-Se semiconductor system affects these photoinduced changes in the optical properties. Addition of germanium, for instance, will make the degree of clearing of an unheated specimen and the degree of clearing or of darkening of a heated specimen dependent on the intensity of the laser. The authors thank I. I. Turyanitsa for supplying the specimens. Figures 3; references 4: 1 Russian, 3 Western.

USSR

UDC 535.317.1

ARTISTIC HOLOGRAPHY WITH RECORDING IN THREE-DIMENSIONAL MEDIA ON THE BASIS OF LIPPMAN PHOTOGRAPHIC PLATES

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 8, Aug 78 pp 1683-1688 manuscript received 15 Dec 77

DENISYUK, YU. N.

[Abstract] Lippman holography is being improved so as to make it feasible to produce a new form of art, namely three-dimensional pictures giving a complete illusion of objects. First of all it is necessary to inhibit the growth of silver halide crystals during their emulsification and to then supersensitize the emulsion layer. It has already been made possible to reduce the crystal dimension to 300 Å by means of an excess KB-concentration and to raise the low sensitivity of such a layer by treatment in a solution of triethanolamine. The next step is to develop a Valenta layer. Available photographic plates include the LOI-2 and the much better PE-1, the latter still in pilot production. Other important trends in the improvement of 3-D holograms include the use of films rather than plates as the medium and the use of pulse lasers as the light source, so that stiff fixation of the photographic layer becomes unnecessary. One problem is the interaction between light and the developed hologram, depending on the exposure level, which will result in a maximum diffraction efficiency. Another problem is modulation of the light beam. While scientific research continues on a limited scale, artistic holography has nevertheless already become a skilled craft. References 41: 36 Russian, 5 Western.

USSR

UDC 778.38

ANALYZING THE RELIEF OF DIFFUSIVELY REFLECTING OBJECTS BY SPECKLE TOPOGRAPHY WITH A WIDE APERTURE

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 8, Aug 78 pp 1696-1699 manuscript received 30 May 77

BOGOMOLOV, A. S., VLASOV, N. G. and SHTAN'KO, A. YE., Moscow Institute of Electronic Machine Building

[Abstract] A method of photographing an object with a laser beam through a plain circular aperture is shown, based on speckle interferometry also applicable to strain analysis. The mechanism of producing a topogram of a surface relief, one which results in diffusive reflection of light, is explained in terms of basic relations in diffraction theory. The sensitivity

and the limitation of this method are also established on this basis so that the optimum aperture for a given object size and distance can be found. The method is similar to holography with two light sources, but here photographic recording plays a principal role. Figures 2; references 5: 1 Russian, 1 German, 3 Western.

USSR

UDC 772.99:778.11

HOLOGRAM COPYING

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1413-1428  
manuscript received 9 Aug 77

VANIN, V. A.

[Abstract] This is a survey of the technical literature on methods of hologram copying and their applicability. Mechanical copying, by casting or impression, is most suitable when original holograms have a surface relief. Optical copying, based on the principle of interference, is universally suitable and characterized by high fidelity as well as the possibility of control over the properties of the original. The copying process is analyzed in terms of the frequency-contrast characteristic and, depending on the gap width between original and copy, takes place within the Fresnel diffraction zone or within the Fraunhofer diffraction zone. In the latter case a reflection-hologram copy can be obtained from a transmission-hologram original. Copying facilities the three-dimensional processing of an image, and improves the diffraction efficiency when the object is diffuse. A copy of optimum quality is obtained from a thick phase hologram, a thin copy of a thin hologram reconstructs two pairs of "dual" images. Copying on grainless photographic films has been found to be most promising in terms of low cost, high diffraction efficiency, and copy quality. One noteworthy application is copying of Fourier microholograms used for storage of digital data or documents. Various devices for copying on a production scale, fast and economically, have been developed. Figures 7; references 80: 26 Russian, 1 German, 53 Western.

USSR

UDC 666.593.5:535

EFFECT OF A LOW-AMPLITUDE ALTERNATING ELECTRIC FIELD ON PLZT-CERAMICS WITH  
'MEMORY'

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1530-1534  
manuscript received 18 Jul 77

KOMPANETS, I. N. and SOBOLEV, A. G., Institute of Physics imeni P. N.  
Lebedev, USSR Academy of Sciences, Moscow

[Abstract] When a low-amplitude alternating electric field is applied to a ferroelectric material with "memory," there occurs a domain disorientation accompanied by heating during polarization reversal, and at some temperature the domain structure together with its birefringence are lost. Both effects are taken into account in analyzing the electro-optical performance characteristics of a ferroelectric PLZT ceramic. The calculations are based on the equations of equilibrium between domains in two states, for an 8:65:35 PLZT rhombohedron in the ferroelectric state at room temperature and with the vector of spontaneous polarization oriented along any of the four body diagonals. The results indicate that large optical contrasts are attainable. The authors thank S. A. Pikin for the helpful discussion and critical comments. Figures 2; references 4: 1 Russian, 3 Western.

USSR

UDC 532.783:621.378.324

HOLOGRAM RECORDING BY MEANS OF A CONTROLLED LIQUID-CRYSTAL TRANSPARENCY  
WITH A CAPACITY OF 128x128 ELEMENTS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1471-1475  
manuscript received 14 Jul 77

MTSKERADZE, G. SH., DOROSHKIN, A. A., KLIMOV, I. I., KOMPANETS, I. N., MAZUR,  
A. I., and SEMOCHKIN, P. N., Institute of Physics imeni P. N. Lebedev, USSR  
Academy of Sciences, Moscow

[Abstract] The performance characteristics of a matrix-addressable liquid-crystal transparency were studied, the object being to optimize the recording of Fourier microholograms with it by electric-field control of scattering. Two glass plates were each covered with 128 transparent strip electrodes of indium dioxide and the clearance between them was filled with a 20  $\mu\text{m}$  thick liquid crystal. Transition from cholesteric to nematic phase was effected by application of an electric field, upon the removal of which the crystal only very slowly relaxed to its original scattering state. The

duration of the control signal as well as the bias voltage and the solid angle of the optical contrast were subsequently matched so as to optimize the optical contrast during readout exposure of the transparency data to a laser beam for hologram recording. Figures 7; references 6: 1 Russian, 5 Western.

USSR

UDC 535.317.1/772.99

PRODUCING REFLECTION HOLOGRAMS BY INTERFEROMETRIC COPYING OF TRANSMISSION HOLOGRAMS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1499-1506  
manuscript received 15 Aug 77

VANIN, V. A.

[Abstract] It has been suggested by Yu. N. Denisyuk that three-dimensional reflection holograms can reconstruct an image in white light. Here the feasibility of producing three-dimensional reflection holograms by interferometric copying of transmission holograms is examined. The gist of the method is to replace the material object with its image, real or virtual, which has been reconstructed by a transmission hologram. An analysis of the process and of the system geometry indicates a higher diffraction efficiency of diffusive objects, which makes this method superior to others, and the possibility of regulating the brightness of the reconstructed image. Experimental work has shown that this method is technologically simple. Figures 3; references 15: 9 Russian, 1 German, 5 Western.

USSR

UDC 522:62

USE OF THICK-FILM HOLOGRAMS FOR INFORMATION PROCESSING OF ASTRONEGATIVES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 7, Jul 78 pp 1513-1517  
manuscript received 2 Nov 77

MANGASARYAN, G. R., SARKISYAN, R. A., KHAYKIN, B. YE., and KHITROVA, V. S.,  
Byurakan Astrophysical Observatory, Academy of Sciences of the Armenian SSR  
Institute of Radiophysics and Electronics, Academy of Sciences of the Armenian  
SSR, Ashtarak

[Abstract] A higher resolution and a higher diffraction efficiency as well as a better restoration of the complex wavefront of the image function in a thick-film hologram make the latter preferable to a conventional thin-film hologram for information processing of astronegatives. On this premise, a method has been developed which involves four stages of processing, namely: formation of an image with a random noise distribution, band filtration of the two-dimensional image spectrum, recording a thick-film hologram of the focused image after filtration, and superposition of the initial image on this hologram by means of a two-beam system during restoration. This method has been successfully tried with an astronegative produced on a Kodak 103 a0 plate through the 2.6 m telescope in the Byurakan Astrophysical Observatory. An inversion filter in the form of a black dot 680  $\mu\text{m}$  in diameter and slightly blurry around the perimeter was used for filtration. The two-beam superposition technique was also used for removing point objects from the astronegative before large structures could be revealed. Figures 3; references 13: 3 Russian, 10 Western.

Plasma Physics

USSR

UDC 537.525

INFLUENCE OF THE TEMPERATURE OF THE GAS FLOW ON A HIGH-VOLTAGE DIFFUSE DISCHARGE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 5 No 5(71), May 78 pp 1159-1160 manuscript received 11 Sep 77

PASHKIN, S. V. and PERETYAT'KO, P. I.

[Abstract] An experimental study was done on the influence that gas temperature has on the characteristics of a high-voltage diffuse discharge. The experiments were done with dry air and commercial nitrogen (about 2% O<sub>2</sub>) with discharge both across and along the gas flow. The static pressure reduced to normal temperature was 80 mm Hg, and the flowrate was 90 m/s. At temperatures below 190-200 K, discharge was always nonhomogeneous and could not be converted to uniform discharge by changing the voltage. A homogeneous discharge showed up at temperatures of 200-240 K. With increasing temperature in this range there was a rise in the current of transition from homogeneous to nonhomogeneous discharge. With increasing temperatures from 240 to 350 K, the voltage of transition from homogeneous to nonhomogeneous discharge decreases somewhat. The critical temperature below which a self-maintained homogeneous high-voltage diffuse discharge could not be achieved in either gas depends on the reduced pressure: with an increase in pressure from 40 to 160 mm Hg, this critical point increases from 120 to 350 K. Figures 2; reference 1 (Russian).

USSR

UDC 533.9.082.76

THEORY OF ELECTRIC PROBES FOR A DENSE SEMI-SELF-MAINTAINED DISCHARGE PLASMA

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 5, May 78 pp 920-926 manuscript received 24 May 76

UL'YANOV, K. N., All-Union Electrical Engineering Institute imeni V. I. Lenin, Moscow

[Abstract] The author considers a semi-self-maintained discharge in which the plasma is created by an external source of ionization. The theory of probes previously developed by the author for a self-maintained discharge plasma is not directly applicable to this case since the expression for the current to the probe depends on the specific form of the source of ionization and recombination. In this paper, the current to the probe is calculated for the flat, cylindrical and spherical cases. The analysis is

analogous to the author's previous work [see K. N. Ul'yanov, "Zhurnal tekhnicheskoy fiziki," Vol 40 p 790 1970]. The equation for the plasma takes the form

$$-\frac{1}{r^m} \frac{d}{dr} r^m D_a \frac{dn}{dr} = q - \alpha_k n^k,$$

where  $m = 0, 1, 2$  for the flat, cylindrical and spherical cases respectively,  $D_a$  is the coefficient of ambipolar diffusion,  $n$  is the density of charged particles,  $q$  is the rate of semi-self-maintained ionization, and  $\alpha_k$  is the recombination coefficient. In the flat case, exact analytical solutions are obtained at any  $k$ . The cylindrical and spherical cases do not allow an exact solution in all cases. The case of  $K = 1$  is considered in this article, and approximate solutions can be found by analogy with the previous paper for cases where  $k$  is different from 1. The use of probes of different configurations for determining plasma parameters is discussed. References 5 (Russian).

USSR

UDC 533.9.082.76

#### STUDYING THE SPUTTER OF ALLOY COMPONENTS IN A PLASMA BY A PROBE METHOD

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 48 No 8, Aug 78 pp 1672-1674 manuscript received 23 Dec 77

DUNAYEV, V. V., ZHIGLINSKIY, A. G., PRESNUKHINA, I. P. and FAFURINA, E. N., Leningrad State University imeni A. A. Zhdanov

[Abstract] A sensitive method of determining the apparent sputter factors for atoms of metallic elements in a plasma is shown, particularly applicable to alloys over a wide range of ion current densities and at low ion energies. A probe of the Langmuir type is inserted into the plasma filling a hollow cathode made of the alloy material under consideration. Atoms of the metal sputtered from the cathode surface condense on the probe surface. The sputter factor for any given alloy component is then calculated according to a theoretical formula which involves the geometric parameters as well as the diffusion coefficient and the sputter time. This method has been tested on grade Kh18N10T steel, containing iron, nickel, and cobalt, as well as on grade PT-7M titanium alloy. As long as the distortion of the plasma by the probe remains small, the results are almost unaffected by variations of the gas temperature over the 500-1000 K range. In order to keep this distortion small, a plasma of a heavier gas should be under a lower pressure. The authors thank M. I. Guseva for the discussion of the results. Figures 1; tables 1; references 7: 4 Russian, 3 Western.

Stress, Strain and Deformation

USSR

UDC 620.169.1

WORK CAPACITY OF CEMENTED JOINTS IN COMPOSITE GLASS SHELLS WITH CYCLIC  
LOADING BY EXTERNAL HYDROSTATIC PRESSURE

Kiev PROBLEMY PROCHNOSTI in Russian No 6(108), Jun 78 pp 90-94 manuscript  
received 5 Jul 77

AMEL'YANOVICH, K. K. and KOZUB, YU. I., Institute of Strength Problems,  
Academy of Sciences USSR, Kiev

[Abstract] Studies are done on the way that the working capacity of items with cemented joints depends on structural and technological factors such as imperfection of the geometric shape of the joined surfaces, roughness due to machining, variations of thickness of the individual shells in the contact cross section, drops in rigidity of shells in the vicinity of the joint, localized contact overloads and the like as the items are subjected to loading by external hydrostatic pressure. The study objects were closed glass shells of revolution consisting of a combination of a smooth cylinder with a smooth hemisphere having identical wall thickness. The cemented joint was made in the middle cross section of the shell. The cement was cold-setting epoxy compound based on ED-6 resin with polyethylene polyamine hardener in a 1:12 ratio. An analysis is made of the causes of damage and destruction of the shells, and steps are recommended for improving cemented joints in shells of this type. It is found that such shells can withstand prolonged cyclic hydrostatic loading under severe working conditions. This high capacity for work is attributed to the fact that the thin layers of cement between the component elements do not produce any appreciable disturbances of the stressed and strained state of the shells. The carrying capacity and durability of composite shells depends directly on the level of torquing of the stressed and strained state. To optimize the capacity of work in cemented joints of glass shell elements, the joints should be located in zones of minimum stress perturbation avoiding the use of structural elements such as flanges, intermediate rings and the like that limit displacements in the shells under the action of external loads. The capacity for work of composite glass shells depends directly on the accuracy of finishing the surfaces to be joined and on matching of their geometric shape and dimensions. Specifically, the mismatch of the outside or inside dimensions of the shells should not exceed 1/10 of the average thickness of the walls of the shells. Greater discrepancies of these dimensions result in a sharp reduction in carrying capacity. Figures 2; references 2 (Russian).

## Superconductivity

USSR

### A NEW SUPERCONDUCTING WEAK LINK

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 20 No 7, Jul 78 pp 2159-2164  
manuscript received 14 Feb 78

GOLOVASHKIN, A. I., LYKOV, A. N., MAKHASHVILI, L. I., and PECHEN', YE. V.,  
Institute of Physics imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] An experimental study was made of a superconductor element consisting of two halves of a superconductive film separated by a narrow slot. Niobium films and tantalum films on polished quartz substrates were produced for this study by vacuum evaporation with an electron beam. In addition, niobium films were also produced by spray deposition in an argon atmosphere. A "weak" link was produced by transverse "cuts" to various depths. The voltage-current characteristics were measured at temperature ranging from 1.9 to 8.1 K. In the case of films not thicker than 1000 Å and with a critical temperature above 7 K, the trend of their voltage-current characteristics as well as the temperature dependence of the latter were found to be similar to those of an ordinary SIS tunnel junction with an energy-gap singularity. This energy-gap singularity decreased with decreasing slot depth and the voltage-current characteristic was then found to become similar to that of a cross-tie or of a tunnel junction with shorts across the dielectric. In this case a current flowed at zero junction voltage and singularities corresponding to voltage jumps appeared. Some films with a low critical temperature were found to have even or odd subharmonic energy-gap structures, depending on the energy characteristics of the Josephson emission. Figures 4; references 15: 8 Russian, 7 Western.

USSR

UDC [.312.62+.332]

### THERMOELECTRIC EFFECTS IN SUPERCONDUCTORS

Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 125 No 1, May 78 pp 19-56

GINZBURG, V. L. and ZHARKOV, G. F., Physics Institute imeni P. N. Lebedev,  
Academy of Sciences USSR

[Abstract] This survey covers the simple phenomenological theory of thermoelectric effects in superconductors based on the two-fluid model and the London equations, and also based on the complex wave function (order parameter)  $\psi$ , with particular emphasis of procedural problems. It is shown that thermoelectric effects do not disappear in the superconductive state, although the fields and currents associated with these effects may be quite

small in comparison with the normal state. The development of research in this area relies heavily on advancement of more sensitive measuring techniques and equipment. The state of the art can be advanced particularly in experiments on nonhomogeneous circuits or bimetal plates of isotropic superconductors, and also on anisotropic (non-cubic) single crystal superconductors. Another interesting area is effects involving the thermoelectric field and Bernoulli potential in superconductors. Superconductor research up to this point has emphasized the equilibrium state. Thermoelectric effects, like heat transfer and sound absorption, can be categorized as nonequilibrium phenomena in the simplest sense of the word, where electrons and phonons are at equal temperature, characterizing the state of the medium locally, but varying from point to point. With an increase in the mean free path by injection of "normal" electrons (quasi-particles), states arise that are no longer described by quasi-equilibrium functions of distribution with temperature. As an example of the unusual situations that arise in this case, the authors point out that with inverse population of electron levels superconductivity may appear with repulsion between electrons, rather than with attraction as in the usual case. In conclusion the authors thank L. P. Pitayevskiy and A. A. Sobinyanin for constructive criticism. Figures 16; references 114: 58 Russian, 56 Western.

USSR

UDC 537.312.62+539.12

#### SUPERCONDUCTIVITY AND ELEMENTARY PARTICLES

Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 125 No 1, May 78 pp 169-194

KIRZHNITS, D. A., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR

[Abstract] The article is the expanded text of a report to the seminar of the Department of Theoretical Physics at the Physics Institute of the Academy of Sciences of the USSR held in honor of V. Ye. Tamm in April 1977. The interaction between elementary particle theory and the many-body problem (especially the theory of superconductivity) is reviewed. Particular attention is given to the line of mutual contacts between these theories that has led to our present unified theories of elementary particles, especially the idea of spontaneous symmetry violation. While other important lines such as those relating to phase transitions close to the critical point are almost ignored, the author has attempted to make the material at the interface between many-particle and quantum-field theories accessible to specialists in both fields. The exposition is not detailed, and is presented on a semi-qualitative level. The intimate and far-reaching analogy between

the unified field theory and the theory of superconductivity is discussed. An examination is made of some of the implications of this analogy as they relate to problems of particle physics and cosmology. The author thanks V. L. Ginzburg, L. V. Keldysh, A. D. Linde and Ye. L. Feynberg for discussion and constructive criticism. Figures 4; references 48: 25 Russian, 23 Western.

USSR

UDC 539.4

#### DESTRUCTION OF SUPERCONDUCTIVE COMPOSITES AT LOW TEMPERATURES

Kiev PROBLEMY PROCHNOSTI in Russian No 6(108), Jun 78 pp 108-113 manuscript received 15 Jun 77

PARKHOMENKO, T. A., PUSTOVALOV, V. V. and STEPANENKO, V. A., Khar'kov, Kiev

[Abstract] Electron microscope studies were done on the fracture surfaces of composite superconductive cable sections in which the superconductor is a titanium-niobium solid solution and the matrix is copper. Tensile loading was used at a constant strain rate of 1 mm/min in a temperature range of 4.2-300 K. The breaking point and maximum uniform plastic deformation were determined from chart-recorded strain curves. It was found that the high ductility of the copper matrix influences the fracture and ductility of the composite at low temperatures. Despite low plastic deformation at 4.2 K, superconductive wires of Nb-Ti show viscous fracture. In addition to the ductility of the matrix, this behavior can be attributed to processes of strain working and heat treatment. Evidence in favor of this hypothesis can be seen in the oriented grain structure on the surface of etched wires with a linear minimum dimension about the same order of magnitude as the size of pits on the fracture surface. The authors thank A. Ya. Krasovskiy for cooperating in the work, and V. A. Startsev for discussing the results. Figures 6; references 7: 5 Russian, 2 Western.

CSO: 1862

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